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# The American Foundry in a Time of War

*Lessons in Shell-Making From the Experience of French Foundrymen —Semi-Steel in Demand—Slip-Shod Methods Cannot be Tolerated*

By Edgar Allen Custer Jr.

IN THE summer of 1914, when the European powers suddenly found themselves face to face with the stupendous task of not only raising and equipping huge armies, but of keeping them constantly supplied with the necessary munitions of war, they proceeded, as systematically and deliberately as the mad rush of events permitted, to organize their industries to the highest possible point of capacity and efficiency. Not only did they tax their own capacity to the utmost but they called upon all the outside help available. Tremendous orders were placed here in America for all sizes and varieties of shells, shrapnel, fuses, and other military stores. We in turn swung our industrial organizations as rapidly as possible into line for high pressure production. Huge tracts of land were plowed up and concrete foundations sprung up, almost overnight, the forerunners of buildings of a size and capacity hardly even dreamed of before. The country was combed from coast to coast for the necessary machines to equip the new shops and every machine tool builder suddenly found himself confronted with his dream of dreams, gigantic orders to be had for the taking.

### *The Tide of Fortune*

The tide of fortune swung on to the foundries and they in turn bent every effort to the task of satisfying the insistent demands of their customers. Patterns for machine housings were swung into the pits while the sand was still hot from the housing pulled out but a short time before. Night gangs were put to work cleaning up and preparing for the day force. In many cases buildings were enlarged. Sheds and outbuildings were constructed around the foundry for overflow molding operations. Every effort was made to meet the sudden demand.

In Europe the same scene was being enacted, more grimly and earnestly perhaps and with the knowledge that their very existence hung in the balance, yet probably with no greater individual effort. The far famed German preparedness and efficiency had, no doubt, foreseen and provided for every detail even to the precise quantity and grade of each type of casting in each foundry. Conditions in France, England and other

countries, however, more closely resembled our own state of affairs, each foundry working to its utmost but with a lack of unity and co-ordination so characteristic of the foundry trade. Each shop produced according to its own methods. Some specialized on heavy castings. Some turned to light work, as their equipment dictated. Various shops used widely different brands of iron for similar work. All were guided solely by the aim to produce in quantity and have sound, strong and easily machined castings, and at first their product was satisfactory.

But as the war assumed greater and greater proportions a new phase began to make its appearance in the foundries. When the first great drives through Belgium and France had come to a standstill and the armies were deadlocked, each protected in endless miles of trenches, the artillery developed into the determining factor. The famous and terrible curtain of fire made its appearance, necessitating the rapid use of great quantities of large and small caliber guns. Every assault upon a trench was dependent upon the artillery preparation that preceded it, during which the concentrated fire from many guns literally blasted the trenches out of the ground and devastated the country for miles.

### *High Pressure Production*

This meant an unceasing supply of projectiles in quantities incredible were it not for the results obtained, and necessitated not only a higher rate of production on the part of the manufacturer but rigid economy if it were to be maintained for any length of time.

As the deadlock wore on week after week it became more and more evident that victory would finally depend upon exhausting the enemy's resources and in an effort both to conserve resources by reducing the cost and to increase the rate of production, the cast-iron shell made its appearance. The first indication were fragments of German shells, picked up on the battlefields of France. They were unquestionably cast iron. Little attention was paid to this phenomenon at first, since cast-iron shells are by no means new. Every country used them more or less for target practice, and it was argued that the Germans were hard pressed and were down to the extremity of using their dummies and target practice shells in active service. But Germany proved far from exhausted and as their guns returned shot for shot, the cast iron shell became an everyday occurrence and, contrary to most beliefs and opinions, observations seemed to prove them just as efficient as the steel shell.

From no less authentic sources than the official French inspectors and from men high in financial and commercial circles, lately returned, we get the story of France's struggle, crowned with final success, to produce a cast iron shell that would measure up to the stringent French requirements. Quick to appreciate the possible economies and the advantages of an increase in the rate of munition production, the French foundries were called upon to produce cast iron shells and solve the problem of meeting chemical and physical requirements calculated to give a shell no less efficient than the steel shell. The exact details may be withheld until long after hostilities have ceased, but many accounts of losses of total heats and 50 and 75 per cent rejections and the final adoption of mixtures identical with our semi-steel, indicate that the struggle must have been difficult and costly.

### *American Foundries Should be Ready*

With our own country today facing the crisis of her history and with the grave realization that, while highly improbable, it is by no means beyond the bounds of possibility that the safety of the nation may rest upon our manufacturing ability, it is well that our foundries be prepared to do their part. Should the demand for shells become so great or the pressure of needed economy so powerful, that we also should turn to the foundries for help it would be everlastingly to their credit if they were able at once to produce a satisfactory product.

The production of cast iron or semi-steel shells presents difficulties that heretofore few if any foundries have been called upon to meet. Not only must they withstand fracture, but they must also behave properly when fractured. Sufficient resistance to impact must exist to prevent fracture and possible detonation within the gun, under the action of the impact of the propelling charge, and at the same time the resistance must not be such that it interferes with the proper fragmentation when detonation occurs.

The range of the physical qualities is limited to almost one precise point that will give the proper fragmentation, and to obtain and maintain this point is essential. Too great a resistance to the bursting effect not only reduces the number of the fragments, but necessarily reduces the destructive capacity of the shell, since too great a proportion of the explosive force is needed to effect the bursting. On the other hand insufficient resistance results in excessive fragmentation in which the pieces are so small that they are not capable of serious damage and lose their velocity quickly, thereby reducing the destructive range of the shell.

A sound casting is absolutely essential, for blow holes, slag spots, spongy areas and shrink holes not only seriously impair the strength of the shell, but tend to interfere with proper marksmanship. The proportions and distribution of the weight of the shell are calculated to a nicety, and the concentricity and position of the center of gravity are the determining factors in governing the flight of the shell. Blow holes or shrink holes may cause enough unequal distribution in the weight of the shell to interfere with its balance in flight and cause it to take a course sufficiently apart from its figured trajectory to strike wide of the mark. Still far more serious is the possibility of a weak spot giving way under the impact in the gun and not only tearing the gun to pieces but endangering the lives of the gun crew. It goes without saying that the casting must be machinable, since a casting too hard to machine could not possibly come within the requirements for fragmentation.

To meet the conditions such requirements call for the average American foundry must make radical changes in its mode of operation. The chemical analysis of the heats must be *exact*, not approximate, as between such and such a percentage of carbon or silicon. Also they must be not only exact but consistent, each day's analysis, melting temperature and speed of operation must be a duplicate of the previous day. The molding conditions must absolutely preclude the possibility of blows, gas or dirty metal. The core making must be practically perfect and the handling of the metal rapid, even and free from delays or interruptions.

### *Cause of Rejections*

Seventy-five per cent of the rejections the foundries of France suffered while endeavoring to produce satisfactory semi-steel shells could be traced directly to the analysis of the mixtures and to this point the American foundry will have to pay the strictest attention. The average foundryman today, while professing to mix his charges by chemical analysis, is forced to admit when questioned closely that he is only approximating the desired result. To be sure he is sufficiently close to meet the requirements a foundry is generally called upon to meet, yet his mode of cupola operation and metal selection would fall far short of producing satisfactory shells. Still further from success, would be the foundryman who mixes his charges by that delightfully uncertain method of accepting the salesman's guaranteed analysis for his iron and coke and "toning" it down with any sort of scrap he may have on hand. Still existing in the midst of the progress foundries have made in controling their analyses, and in a surprisingly large number of cases, we find the foundry-

man, generally the old timer who "didn't learn his trade from books", who scorns percentages and proportions and mixes his charges by his own rule of reason. His analysis consists of breaking one pig over another and examining the fracture, and his mixing is generally some of the soft and some of the hard and the rest of it scrap. The shell his foundry could produce may look like a shell in size and contour but there the resemblance ceases.

To successfully produce semi-steel shells designed for active service, the services of a chemist are absolutely essential. His control and authority should be absolute, and upon his shoulders should rest the burden of the full responsibility for the mixtures, and under his direction should come every detail that relates in any way to the chemical composition of the semi-steel. Every facility should be afforded him to make and record his various analyses and observations, and his equipment should include the scleroscope and micro-photographic outfit.

*Analysis of Materials*

Each car of pig iron should be sampled, resampled, carefully analyzed and piled in such a manner as to prevent confusion with any other pile. The piles should be lettered or numbered for future identification. Every car of coke must be of the highest grade both in respect to analysis and body, particular attention being paid to the sulphur, for a poor grade of coke or a coke too high in sulphur is capable of untold damage.

The ordinary method of using scrap must come under a ban if best results are to be obtained. Under no circumstances should the scrap be charged direct into the cupola as a part of mixture. It should be charged alone at the end of the heat and run off into pigs or chills. Each lot of recast pigs or chills must be kept separate and, as in the case of the pig iron, sampled, analyzed, piled and marked for identification. By so handling the scrap all possibility of error due to unknown qualities is eliminated.

The grade and character of the steel are of less importance, since, compared to cast iron, the analysis of ordinary steel is practically stable. A wide range of physical properties may be obtained in steel with practically no change in the chemical properties aside from the condition of the carbon, and as the carbon reverts entirely to combined carbon during the process of melting, the condition of the carbon in the steel has no bearing on the analysis of the semi-steel. In the production of semi-steel any ordinary grade of steel is serviceable, such as boiler scrap, steel stamping or punching scrap, etc., provided it is not so thin and light in section as to be bulky when charged into the cupola, thus interfering with the proper charging. The use of alloy steel is to be avoided as the attainment of the proper chemical and physical requirements for semi-steel shells is too delicate a proposition to risk the evil influence it may or may not have.

The preparing and charging of the cupola should be carried on under the direction of the chemist and with just as much care and attention to detail as the chemist uses in his laboratory determinations. The method of laying, lighting and burning-up the fire should absolutely eliminate the possibility of a poor start, for such a start may spoil a whole heat. The addition of extra fuel after a cupola is well under way, while it may have the desired effect of regaining the proper melting temperature, may also be just enough to upset the analysis sufficiently to result in poor fragmentation. Also a poor start means that quite a proportion of the first metal charged is melted at a temperature below that necessary to produce satisfactory semi-steel. This may result in as much as 20 or 30 per cent of the heat being unfit for use.

All pigs, whether they be from the blast furnace or remelted scrap, should be broken into short, fairly uniform sizes so they may be placed uniformly in the cupola and melt practically simultaneously. Small pigs also facilitate weighing and make it possible to reduce the charging error in weights from pounds to ounces. All components of the charge, whether they be iron, coke, steel or scrap, should be carefully weighed and charged according to formulas and the prescribed quantity of each should be just as close as it is practical to obtain, all guessing and approximating being avoided.

*Importance of Cupola Operation*

The average method of cupola operation in this country sets at nought any close or accurate work on the part of the chemist. Too often the work of weighing and charging is left to the care of the laborer on the platform who goes through the operations of weighing and charging with scant regard for anything except speed. Too often the given quantity is measured as so many average pigs, or so many buckets or forks of coke and generally some more for good measure. Such cupola operation may produce excellent sash weights or grate bars and some classes of heavy work, but it would be an absolute impossibility for shell work.

The melting temperature, as determined by the appearance of the metal as it flows from the cupola, should be kept as constant as possible and at a temperature slightly above normal, in order that the timing operations for handling and pouring can be reduced to a science. Semi-steel, like cast iron, will absorb or throw off impurities according to its melting temperature, absorbing impurities, particularly sulphur, when the temperature is too low, and throwing them off when high, so it is essential that the temperature be kept as high as possible, although care must be taken not to burn the metal.

In handling the metal, it was found that the best results could be obtained by using a specially constructed receiving ladle under the spout of the cupola. This ladle, mounted on trunnions, is so constructed or so lined up that the metal flowing over the lip is drawn from the bottom of the ladle, similar to a spout or skimming crucible. This effect can be obtained by taking an ordinary large foundry ladle and placing a fire brick partition running down just behind the lip, parallel to the side of the ladle, to a point several inches from the bottom. The metal to flow over the lip must then first flow down behind the partition, under it and up over the lip. This insures clean metal and gives the air and gas an opportunity to escape off the surface of the metal in the ladle. It performs the functions of a mixing ladle.

*Ladle Preheating*

The metal should then be transported as rapidly as possible in small ladles with but one change in order to eliminate any unnecessary chilling or oxidizing of the metal.

All ladles and the cupola spout should be thoroughly dried before using and the ladles should be kept over a fire or in a warm place until it is time to use them. The first metal down should be used to preheat both the large and small ladles and then poured into the chills or pigs. Metal which shows any boiling or agitation due to an imperfectly dried lining should never be used even though it eventually comes to rest. Such iron should be poured into the pig bed. When the ladle is once heated up it should be kept going constantly until the end of the heat to prevent its getting cold and chilling the metal.

Second in importance to the chemical analysis and the means of obtaining it comes the molding of semi-steel shells. So many rejections and so much trouble could be traced to the use of green sand that its employment has been practically prohibited. The formation of gas and blow holes resulting from the action of the hot metal on the damp sand, and the sand cut from the mold and carried into the shell produced such wholesale rejections that the dry-sand mold became a necessity. One report, in particular, states that one foundry situated in northern France failed to produce a

single satisfactory heat until green sand molding was abandoned. The character and grade of the sand and the method of molding varied according to the size of the shell made, and according to the equipment and familiarity of each individual foundry. Two requirements only seemed to be in common. *First,* the sand used and the binder and form of venting were such that the mold was absolutely free venting and porous, and *second,* every mold was provided with some form of trap gate to serve the double purpose of trapping any slag or dirt in the metal and removing air or gas that may be trapped in the metal.

Too much attention can not be paid to the use of the trap gate in molding with semi-steel, especially when the product is shells. A large number of foundrymen look upon it as one of those newfangled ideas to assist incompetent molders. They believe they are fully capable of keeping dirt and slag from entering the mold without such a gate. Such may be the case, but the molder does not exist who can pour a swift rush of semi-steel with the speed necessary to produce perfect shells without trapping air and carrying it into the mold. Ordinarily this air is free to escape through the porous sand, but often the first splash of the metal forms a thin skin or shell which seals the air in and results in the formation of the small holes familiarly known as gas holes.

*Vertical Molding Discontinued*

The position of the casting when poured was a point that gave considerable trouble when the French foundries first started on semi-steel shells. It was at first considered necessary to pour the casting on end, either point or base up, and to allow extra metal on the cope to collect dirt or gas holes and to provide metal for possible shrinkage. This form of molding, while satisfactory in so far as the quality of the shell was concerned, had two disadvantages. It necessitated extra machining to remove the excess metal and it was a difficult molding operation. As the various operations were reduced to a scientific basis, it was noted that the extra metal was no longer a necessity, and a great many foundries discontinued the vertical form of molding. This enabled them to use the match plate form of machine molding and to mold the shells in pairs, using a balanced core.

In order to obtain a record of the grade of the metal during the course of the heat, practically all of the foundries at first adopted the method of casting test pieces at various times during the heat. These test pieces were examined in various ways and the results compared to the mixture, or to he method of operation which had been used at the time the metal represented by the test piece was charged. Some adopted the plan of casting against a chill, breaking the piece and observing the depth of the chill. While satisfactory to a degree, there was one serious objection to this method. The depth of the chill is determined by two factors, the chemical analysis and the temperature of the metal at the time it strikes the chill; it was difficult to determine which might be responsible for an error in the depth of the chill. A ladle of iron or semi-steel of a given chemical analysis may be productive of a series of depths of chills which vary according to the temperature of the metal when poured. The depth of the chill is greatest when the metal is at the highest temperature and if poured at a very low temperature, where the metal is becoming mushy, the chill can be reduced to a mere skin. This fact resulted in the production of test pieces of varying depths of chill which did not vary chemically to a corresponding degree, when the unchilled portion was analyzed. This resulted in confusion and uncertainty as to the accuracy of the tests. Other foundries ground a spot on the test piece and used the scleroscope for the test, while others resorted direct to chemical analysis.

Any method of examination, however, proved of little value, except as a matter of record for future reference, for the particular portion of the heat represented by the test piece was already melted, and any change made in the mixture in an effort to correct the analysis did not affect the metal until some eight or 10 charges later when, in all probability, it was not needed. When the form of investigation depended upon the scleroscope or the chemical analysis this discrepancy in time was increased by the time necessary to prepare the piece and make the determination. For this reason any attempt to use the test pieces for the purpose of enabling the foundryman to make a correction during the heat was abandoned, and if the casting of test pieces was continued at all it was only as a matter of record.

The cleaning of the shells is a matter that may be left to the individual foundryman, although the most satisfactory method in France seems to be tumbling and pickling in a hydroflouric acid solution. The tumbling serves to remove the sand adhering to the surface and to knock or rattle out the core, while the acid bath following insures practically a naked iron which facilitates machining. Sand particles are eaten out and spongy spots or porous areas, that are frequently not easily detected after tumbling alone, are exposed.

Too much attention cannot be paid to the inspection of the product. It should be severe and thorough. Every piece passed should have been inspected not only for soundness and size, but for weight, strength and texture. The scleroscope should be used on several spots on each piece and the shell should be subjected to a hydraulic test to develop any holes or strains. A rigid inspection before the casting leaves the foundry will save many hours useless labor on shells which develop defects during machining or which fail to pass the ballistic test. The economy effected is sufficient to warrant the utmost care and thought.

The story of the difficulties encountered and the financial losses incurred, due to ignorance of the requirements, when our various industrial establishments first undertook to make foreign munitions, is familiar to all. So with the experience of the French foundries to guide, bearing in mind the lessons from many munition failures in America, our own foundries should be prepared to do their part, should, by any chance, the swiftly changing current of events necessitate a call upon them.

## Castings With a White Core

*By W. J. Keep*

*Question*:—We are experiencing difficulty resulting from the chilling of small castings, a sample of which has gone forward under separate cover. It will be noted that the center of the casting is chilled, whereas a gray exterior surrounds this chilled portion. One man pours off 180 molds of these castings per day, or 2,160 pieces. We find about 50 to 100 of these castings showing this peculiarity in a day's work from some of the floors. As tapped from the spout, our iron contains 3.05 per cent silicon and 0.099 to 0.107 per cent sulphur. Our charges consist of 400 pounds of new iron, 600 pounds of remelt, and 100 pounds of coke. We melt at a blast pressure of from five to seven ounces. In breaking up the pig iron we occasionally find some chilled fracture. Our iron runs in a continuous stream and is carried away in hand ladles as fast as melted.

*Answer*:—The fault is not in your iron. The first iron falls on a damp cupola bottom, at least it boils because of either the steam or gas from the cupola bottom. The first iron is caught in a ladle that has not been used before and the iron boils again. If this is poured into another ladle to dry it, and it boils again, it will probably produce castings gray on the outside and white in the center. The first 300 pounds of iron should be used in drying ladles and poured into the pig bed or into castings. If the molder will catch the first iron and pour it into his mold, hard spots will not occur.

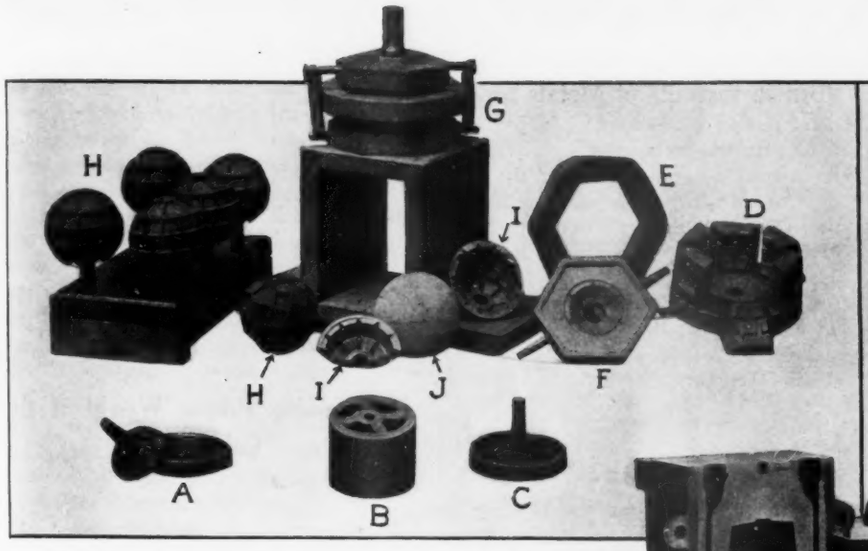


Fig. 1—Cores and Core Boxes for French Grenades

# Molding Shells and Grenades for the French Army

TO PERSONS who have not had actual experience in a country where every effort is centered upon ultimate victory on the battle front, the important part played by the modern foundry in creating implements of war is only vaguely realized. In France, foundries have been diverted from peaceful pursuits to a basis of war business in a comparatively short time and the efficiency which has been developed is remarkable..

Not only have the French foundries been called upon to furnish a great variety of castings for various machines indirectly utilized for military purposes, but they have been required to enter directly into the munitions field. One of the interesting phases of this new work is the making of grenades. Fig. 1 shows the evolution of a core for spherical grenades used by the French armies. A complete grenade casting is shown at *J* and sectional parts of grenades are shown at *I, I*. The exterior of the casting is a perfect sphere, while the interior is marked by deep staggered grooves. The presence of these grooves involves the use of a spherical core having web-shaped projections on the outer surface. *B* is the core box, in which the lower or small core *A* is made. In building up the entire core, the part *A* is placed in an inverted position in the bottom section of the core box *D*. The band *E* is then placed around the six side sections of the core box and the sand is placed in the box. After it has been rammed, the top section of the box, *F*, is put in place and additional sand is applied through the hole in the top. The springs shown in *G* are then applied to hold the drag and cope tight to the cheek and additional sand is added through the hole in the top. After the sand is rammed, a plug is inserted in the hole and the ring may then be taken from the cheek so that the six sides may be expanded to allow the core to be removed. The finished cores in position for baking are shown at *H, H*.

FIG. 2—HYDRAULIC MOLDING MACHINE FOR HAND GRENADES

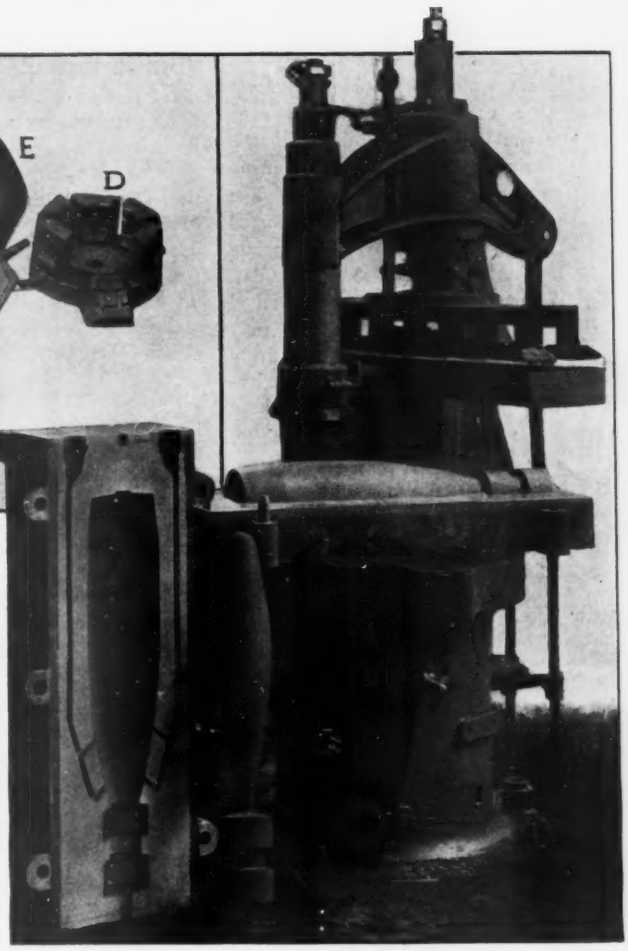

FIG. 3—HYDRAULIC MOLDING MACHINE FOR 155-MILLIMETER SEMI-STEEL SHELLS

Another form of grenade is made on the hydraulic molding machine shown in Fig. 2. Machines of this kind are designed for flat work, two flasks being rammed at the same time. White-metal or cast-iron match plates are used. The flasks are barred and can be poured either in a horizontal or vertical position. Molds can be made on these machines in from one to two minutes, according to the difficulty of the work. The molds shown in Fig. 2 are for small hand grenades used by the French. It will be noticed that the mold has been arranged to be poured in a horizontal position, two pouring gates being provided in the cope. Each mold will make 18 grenade castings. These grenades differ from the one shown at *J* in Fig. 1, in that the exterior surface is webbed and the interior is smooth. This simplified the coring and plain eliptical cores having axial core prints as shown in the foreground of Fig. 2, are used. Figs. 3 and 4 illustrates a type of hydraulic molding machine used extensively in

France for molding semi-steel shells. Fig. 3 shows a mold for a 155-millimeter shell. One casting is made in each flask and the mold is split in half, each part containing half of the pouring gates, runners and core prints. The core shown at the right is supported in the mold by means of core prints as the bottom and chaplets at the sides. After the flask is set in the vertical position for pouring, the chaplets may be drawn out, leaving the core entirely supported by the core prints. The hydraulically operated molding machine shown in Fig. 3 is capable of making from 15 to 20 shell molds per hour.

The mold for two 90-millimeter semi-steel shells is shown in Fig. 4. The method of molding and pouring these molds is similar to that used in the case of the 155-millimeter shells except that a single gate and runner delivers metal to both molds. The output of the smaller shells on a hydraulic machine is from 15 to 20 molds per hour.

The use of hydraulic pressure for molding machines in France was given a marked impetus by the great demand for war materials. It is claimed that the hydraulic machines operate with a steady motion and that high pressure may be secured and controlled with comparative ease. The pressure for the average molding machine varies from 750 to 1,500 pounds per square inch, enabling the designer to keep the diameter of the rams to a reasonable limit and yet attain an adequate total pressure. This has permitted the design of large machines with a static pressure of as high as 80 tons. Small pipe of from ½ to ⅞-inch inside diameter is of sufficient strength and size for all piping used in connection with these machines.

Most French companies have found that it is more economical to use strong and uneducated laborers on molding machines than to employ molders who have a better knowledge of foundry practice. Since the war many women have been working on molding machines and they do exceedingly good work, especially on light and medium-sized molds. Piecework is preferred as the basis of payment in many French foundries, but there are a number of employers who favor the premium system of payment. Men who prefer the latter system feel that the piecework price, when once set, is a source of difficulty with the men. With the premium system, they claim, these difficulties may be more easily adjusted. Advocates of the piecework system, however, contend that if an equitable piecework price is determined after sufficient study of all conditions entering into this price, no trouble is experienced and the piecework method of payment tends to increase production.

## British Institute of Metals Meets

Interesting discussions of subjects pertaining to the melting of metal featured the annual general meeting of the Institute of Metals in the lecture hall of the Chemical Society, London, March 21 and 22, 1917. Among the important papers presented in abstract at the two sessions of the meeting were articles on the "General Properties of Stamping and Chill Castings in Brass" and "Machining Properties of Brass", by Owen

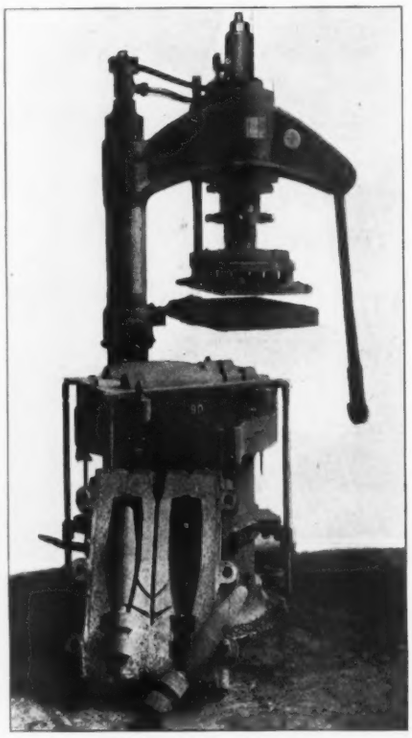

FIG. 4—HYDRAULIC MOLDING MACHINE FOR 90-MILLIMETER SEMI-STEEL SHELLS

W. Ellis, London; "Surface Tension and Cohesion in Metals and Alloys", by Sydney W. Smith, London; "Aluminum Production by Electrolysis", by R. Seligman, London, and "Annealing of Nickel Silver", by F. C. Thompson, Sheffield.

In the discussion of metal melting, W. J. Hocking, London, reviewed a paper describing the process employed in molding metal at the royal mint. G. B. Brook, Sheffield, discussed coal gas as a fuel for melting non-ferrous alloys, and C. M. Walter, Birmingham, spoke on high pressure gas melting. H. C. Greenwood, London, and R. S. Hutton, Sheffield, contributed a paper on "An Electric Resistance Furnace for Melting in Crucibles". Other discussions were contributed by H. M. Thornton, H. Hartley, Carl Hering and H. S. Primrose.

In the general discussion considerable attention was given to fuel economy in the operation of melting furnaces. The importance of the subject, which apparently has been brought to the attention of foundrymen by the unusual requirements of metal for munitions making in England, was particularly emphasized in a number of the papers read. It was shown that the lack of comparative data had been responsible, in many cases, for failure to adopt efficient means of metal melting. The meeting was in charge of Sir George Beilby, head of the new government board of fuel research.

## Determining Proper Weight of the Coke Bed

*By W. J. Keep*

*Question*: — Our cupola is lined to 45 inches, and the distance from the bottom of the furnace to the bottom of the tuyere openings is 15 inches. It is provided with six sets of tuyeres, each having three openings, 5 inches high and 5 inches long, making a total outlet area of 435 square inches. We charge 3,500 pounds of iron and 1,450 pounds of coke on the first charge and 3,000 pounds of iron and 280 pounds of coke on the succeeding charges, and are obtaining satisfactory results. However, we have been informed that the coke beds should be from 20 to 24 inches deep after it is burned down. Assuming that the 20 to 24-inch height should be above the tuyeres instead of above the bottom, I would still have 18 to 22 inches too much coke on the bed. Prior to my employment in this foundry, it was the practice to charge 2,500 pounds of iron, but with the same amount of coke as indicated. However, we gradually increased the iron charges with the result that the good casting ratio increased above what we had formerly with the higher fuel melting ratio. We would like to know whether we are getting all that we have a right to expect and we would like to know whether the advice we have had regarding the height of the coke bed is correct.

*Answer*: — Everything that you have done seems to be right. I assume that you have only one row of tuyeres in six groups each, having three openings, or practically six tuyeres, each 5 x 15 inches. If this is so, you should reduce the bed 25 pounds each day until you have reached a point where this reduction is sufficient. In my practice I endeavor to have the coke extend 15 to 18 inches above the top of the tuyeres when the iron is about to be charged. It would be advisable to slag the cupola, as this will improve the results. However, it is advisable to go slow in making changes, since the results outlined by you seem to be unusually satisfactory.

# New Converter Plant for Economical Operation

***Novel Method of Handling Metal in Cupola, Converter and Ladle Reduces Amount of Equipment Required—Cleaning Room Facilities Unusually Complete***

I WISH I had a dollar for every statement I have heard to the effect that "all foundries are the same". Talk with almost any foundryman and he will tell you that a particular casting plant "is just like all the others".

The last man to reveal this remarkable fact to me was Tom Marshall, beaming salesman of the United Foundry Equipment Co. When he learned that I was going to Springfield, O., to secure a description of the new converter foundry of the Blackwood Steel Foundry Co., he assembled all of the cynical sagacity of his 20 years in the foundry equipment business in an effort to prove to me that Blackwood's plant was no different from the many other converter foundries in the country.

"What are you going to write about the place?" he demanded. "I've seen Blackwood's establishment, and believe me, he has a good line of equipment and knows the business, but his shop looks like all the others. All you can say is that he has a new plant, that each building is so many hundred feet long and so many feet wide, that the melting equipment consists of so and so, and that the cleaning apparatus was installed by Smith, Jones & Co. As far as I can see, all you can possibly do is to write the same old story. Why don't you describe a plant where there is something new to talk about?"

**Editor's Note**

*Personal impressions are always interesting. Conventional plant descriptions, on the other hand, are prone to be as dry as dust. The accompanying article presents in a frank, personal way the essential features of the organization, equipment and methods of the Blackwood steel foundry. The editor believes this method of treatment will commend itself to the readers of The Foundry. It's the next best thing to taking a stroll through the shop yourself.*

Not having seen the Blackwood foundry I could not bring forth tangible proof that it was "different", but I carefully assured Marshall that I would surely find something unusual in the Springfield casting plant.

"Oh, that's all right to say. The optimism of the cub is still at high tide in your veins. You'll get over that. I suppose you will come back with the same dyed-in-the-wool yarn that every trade journal has been using in the last 20 years in describing new plants and their equipment."

With this parting shot, he left me pondering over the question his frank remarks had aroused. Are or are not all foundries alike?

* * *

After a brief survey of the various departments of the Blackwood foundry I had the feeling that possibly Marshall was more nearly right in his contention than I. As he had said, to all outward appearances there were few marks to distinguish the plant from any of the many converter foundries in the country. The only noticeable feature that I observed was that the cleaning room equipment was unusually complete. In fact, I could recall only one or two foundries in which the sand-blast apparatus accommodated the large range of castings handled by this equipment in the Blackwood plant.

Satisfied that in the main, the equipment was not of sufficient novelty to warrant a lengthy description I turned my attention to the methods of operating the foundry, and here I found the features which distinguish this steel foundry from all others. In reading the following account of what I learned at Springfield, the reader will realize that every plant has its individual characteristics. Two plants with identical equipment throughout

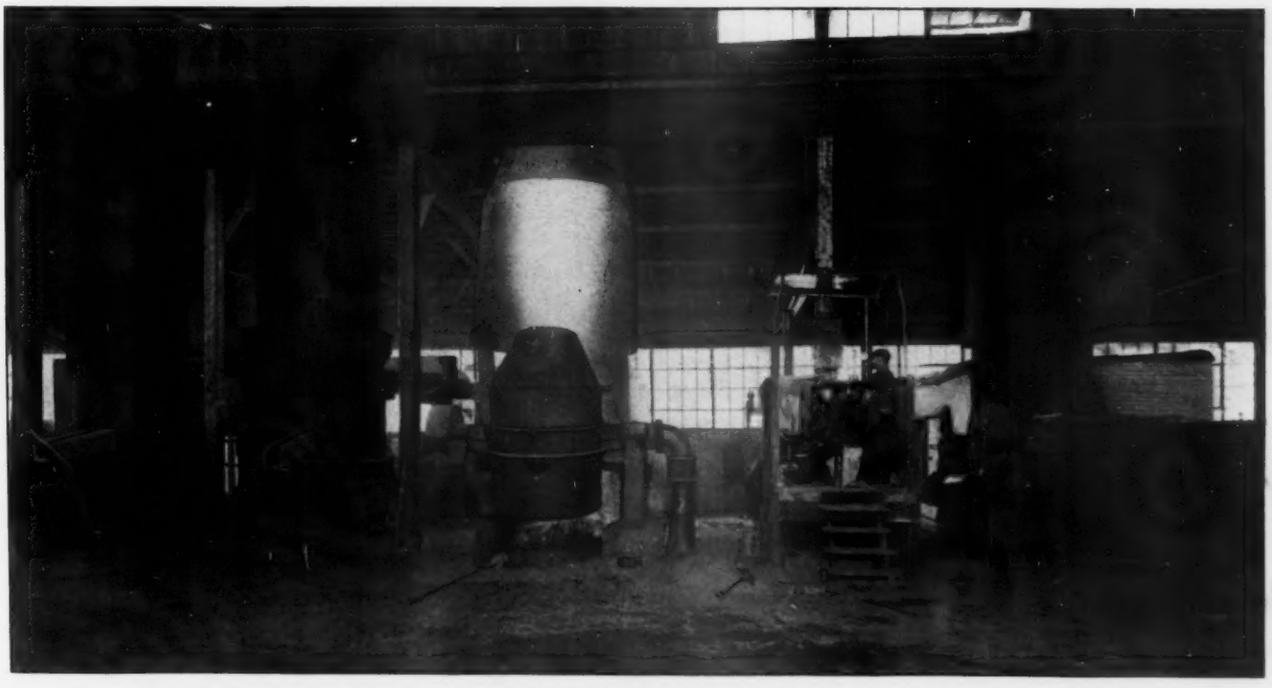

FIG. 1—ARRANGEMENT OF MELTING EQUIPMENT—THE MANNER IN WHICH THE DESIGN OF THE TWO-PIECE CONVERTER FACILITATES RELINING IS INDICATED AT THE RIGHT

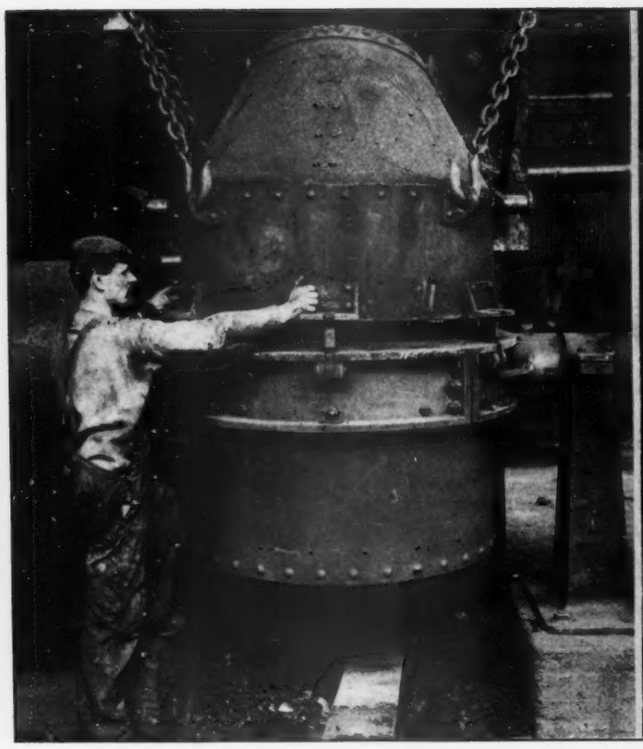

FIG. 2—SHOWING HOW TWO-PIECE CONVERTER IS PARTED ABOVE TRUNNIONS

FIG. 3—REPAIRS TO LINING ARE SIMPLIFIED BY TWO-PIECE CONSTRUCTION

every department may be similar physically, but as long as they are under separate managements, different ideas of operation will be reflected by the methods employed in making castings. And that is the reason that there is a "story" in every foundry.

*Making Converter Steel*

The steelmaking process at the Blackwood foundry is interesting. The melting equipment is composed of two specially designed cupolas of the blast furnace type and two 2-ton side-blow Tropenas converters of the Blackwood two-piece type. The cupolas which are 36 and 56 inches inside diameter, respectively, are charged with a mixture of approximately 65 per cent scrap and 35 per cent pig iron. Thirty per cent of the scrap is made up of the risers, heads, etc., from the cleaning room, and the remainder is a high grade of shell discards. The cupola is operated so that approximately 8 tons of metal are always in the process of being melted, this amount being sufficient for four 2-ton charges for the converter. A blower made by the P. H. & F. M. Roots Co., Connersville, is connected in series to the cupolas, and may supply the blast to either or both as desired.

A full charge of metal is tapped from the cupola into a 3-ton ladle handled by a 5-ton electric traveling crane built by the Toledo Bridge & Crane Co., Toledo, O. After the metal is blown it is poured into distributing ladles and delivered to the molds by hand.

The efficiency of the melting equipment is greatly increased by the special design of the cupolas and converters and by the system of operation. By constantly maintaining a sufficient amount of metal in the cupola to provide for four blows of the converter, the heating value of the coke is considerably increased, enabling the use of a one-to-seven ratio of fuel to iron.

FIG. 4—SPRUES, GATES AND RISERS ARE REMOVED BY MEANS OF ACETYLENE CUTTING TORCHES

*Advantage of Two-Piece Converter*

The two-piece arrangement of the converters greatly facilitates relining and permits the use of one converter continuously for a full day while the other is being relined. As shown in Fig. 2, the two-piece converter is similar in all respects to the ordinary bessemer unit except that the shell is in two parts, the line of division being a ring just above the trunnions. This arrangement makes it possible to remove the upper part

of the shell from the lower half, thus making the interior of both sections accessible for relining. A detailed description of the two-piece converter, which is an improved type of the Tropenas unit patented by A. F. S. Blackwood, appeared in the February, 1913, issue of *The Foundry*. At the present time from 20 to 22 blows are taken from the converter each day.

As I watched the workmen in the act of carrying hot metal from the tilted converter to the molds in small hand ladles I was again reminded of the "all the same" arguments of my friend Marshall. Here, evidently, the method of distributing metal employed in the typical foundry was being followed to the letter. Just as I was about to dismiss the pouring process as an impossible feature for my story my attention was called to a couple of brackets riveted to one of the building columns. As their purpose was being outlined to me, I had visions of again upholding my contention with the salesman, for the brackets are the forerunners of a system of metal distribution that will mean a remarkable saving in time, labor and equipment.

FIG. 6—UNUSUAL VIEW OF INTERIOR OF ROTARY TABLE SAND BLAST CHAMBER

### *A Unique Pouring System*

Under the present system of pouring, the converter is merely a ladle during the time the metal is being carried from it to the molds. When the four heavy brackets situated at convenient points in the foundry are installed, the entire blow from the converter will be poured into a large tea-pot ladle carried on the hook of the 5-ton crane. This ladle will be carried to one of the four brackets, which is at the proper height from the floor to bring the spout at a point convenient for pouring into the small distributing ladles. This arrangement will enable the converter to empty its charge in less than a minute. The slag can be run out, a new charge deposited from the cupola, and under favorable conditions, the bessemer unit be placed in position for blowing five minutes after the last melt has been discharged. Experienced foundrymen will have already concluded that this method also releases the crane for other duties as soon as the tea-pot ladle is placed on one of the brackets.

### *Heating Relined Ladles*

This plan naturally necessitates the use of a larger number of ladles, and in order to facilitate their heating an ingenious apparatus has been devised. Cast frames about 5 feet square are held in a vertical position and lined with fire brick. A hole of sufficient size to allow the entrance of

FIG. 5—VIEW OF THE MOLDING FLOOR—THE SMALLER MOLDS IN THE FOREGROUND ARE MADE ON SQUEEZERS AND THE LARGER ONES AT THE END OF THE BUILDING ARE MADE ON ROLL-OVER JAR-RAMMING MACHINES

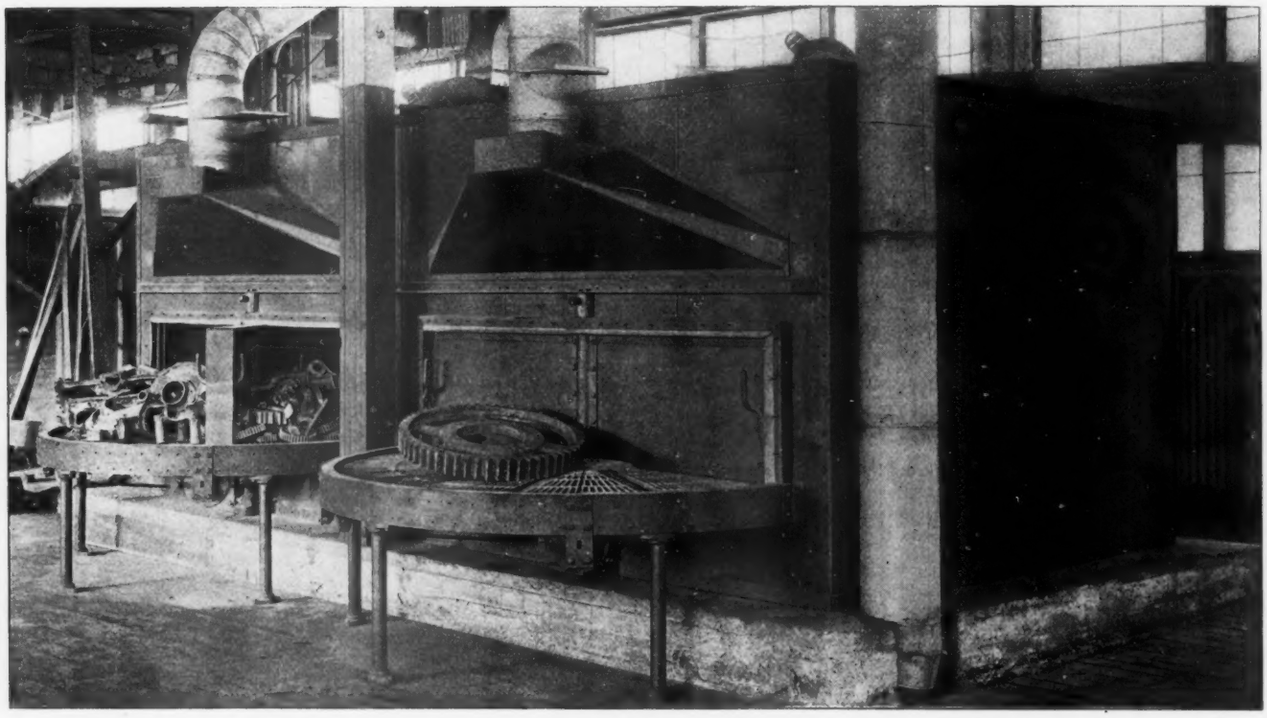

FIG. 7—CASTINGS TOO LARGE FOR THE SAND BLAST BARREL ARE CLEANED ON THIS ROTARY TABLE MACHINE—UNUSUALLY LARGE CASTINGS ARE CLEANED IN A SAND BLAST CHAMBER

the flame from an oil torch is left in the center, and a torch with oil and air connections is fastened to the back of the vertical frame. The ladle to be heated is placed in front of the frame with the edges tight against the fire brick. When the torch is lighted, the flame is directed against the bottom of the ladle, and since the fire brick in the frame makes the ladle an enclosed chamber, practically all of the heat is expended in heating the lining.

Molding sand is handled in an unusual manner. Castings are shaken from the molds as soon as possible after they are poured. The old sand is cut over by a sand mixing machine built by the Sand Mixing Machine Co., New York, and the excess which is not used for backing is carried to a dry pan made by the Frost Mfg. Co., Galesburg, Ill., in trucks furnished by the Lakewood Engineering Co., Cleveland, drawn by a storage battery tractor built by the Automatic Transportation Co., Buffalo, N. Y. The sand is carried from the molding floor to the dry pan at night, and this allows time for the tractor batteries to be charged during the day while the tractor is not in use. Facing sand is made up from three parts of new to eight parts of floor sand, and calculated on a monthly basis for molding and core sand, the ratio of new sand to old is approximately one to six. The sand is sifted through gyratory riddles made by the Great Western Mfg. Co., Leavenworth, Kan., and is rammed by pneumatic rammers manufactured by the Chicago Pneumatic Tool Co., Chicago. Compressed air is furnished by an Ingersoll-Rand compressor situated in a small building which houses a Westinghouse motor-generator set, together with transforming apparatus.

FIG. 8—LARGE ANNEALING FURNACE—ALL CASTINGS ARE SUBJECTED TO A HEAT OF 1,600 DEGREES FOR ONE HOUR, THE TEMPERATURE DROPPED TO 1,500 DEGREES, AND THE CASTINGS DRAWN OUT

switchboard, and the usual accessories.

Small-sized castings are molded on a battery of 18 roll-over and pattern-draw squeezers built by A. Buch's Sons Co., Elizabethtown, Pa., and the larger molds are made on two combination jar-ramming turn-over power-draft machines manufactured by the International Molding Machine Co., Chicago, and a similar machine built by the Tabor Mfg. Co., Philadelphia. Two smaller roll-over, jar-ramming machines manufactured by each of the two last named companies are used in the core room. The molds are dried by oil torches made by the Hauck Mfg. Co., Brooklyn, N. Y., and the Mahr Mfg. Co., Minneapolis, Minn.

Small cores are made in a Hammer core machine built by the Brown Specialty Machinery Co., Chicago, while the large ones are made in core boxes by hand. Small cores are baked in two gas-fired Crawford sectional ovens built by the Oven Equipment & Mfg. Co., New Haven, Conn. A Connersville blower provides the blast for these ovens. Large cores are baked in a double-chamber, coke fired oven designed and built by the Blackwood company. Angle irons fastened on the interior walls of the oven at convenient heights form supports upon which the metal trays carrying the cores are placed.

### *Cleaning Room Operations*

Every casting is shaken from the mold and carried to the cleaning room before the completion of the day's work in the foundry. The sequence of operations in the cleaning department is as follows: Sand-blasting; cutting off sprues, risers, gates, etc.; first inspection; electric welding; grinding; second inspection; annealing; tumbling; and third inspection. If the third inspection reveals defects that may be overcome by welding, the casting is sent back to the welding room, and from there it passes through all of the subsequent operations again.

The sand-blasting equipment consists of a large sand blast barrel furnished by the Brown Specialty Machinery Co., Chicago; a twin-chamber rotary-table sand-blast machine, shown in Figs. 6 and 7; and a sand-blast room. Dust from the sand-blasting equipment and from the grinders, tumblers, etc., is blown into dust arresters situated on elevated platforms about 30 feet from the cleaning room. One of the arresters, with accompanying flues from the cleaning room, is shown in Fig. 9. The rotary table machine, sand-blast room, and arresters were manufactured and installed by the Pangborn Corporation, Hagerstown, Md. The three types of sand-blast apparatus accommodate castings ranging in size from one ounce to more than 500 pounds. Small pieces are cleaned in the barrel; medium-sized castings are blasted in the rotary-table machine; and large and bulky castings are cleaned by means of a hand-operated sand-blast nozzle in the sand-blast room.

The castings are trimmed by means of a sprue cutter and acetylene cutting torches, and then, after being inspected, are sent to the welding department for attention. The electric arc-welding apparatus which was manufactured and installed by the Lincoln Electric Co., Cleveland, is enclosed in a room next to the sand-blast apparatus. Blow holes, shrinkage cracks and misruns are repaired by this electric process, after which the rough surfaces of the castings are ground. The grinding equipment consists of six two-wheel floor grinders made by the Safety Emery Wheel Co., Springfield, O., and four swing grinders designed by the Blackwood company. The swing grinders are unusual in that no babbitt is used in their construction, all bearings being of the roller type. The second inspection follows the grinding operation.

All castings are annealed in a large coal-fired annealing furnace built according to a design worked out by the George J. Hagan Co., Pittsburgh. A charge of castings is left in the furnace for a period of one hour at a temperature of 1,600 degrees, the temperature is then reduced to 1,500 degrees, and the castings are drawn from the furnace at this temperature. While still hot, they are placed in the three 72-inch exhaust tumblers made by the Whiting Foundry Equipment Co., Harvey, Ill. The annealing furnace temperature is indicated by a Brown electrical pyrometer made by the Brown Instrument Co., Philadelphia.

The Blackwood Steel Foundry Co. is an Ohio corporation capitalized at $400,000. The officers of the company are: A. F. S. Blackwood, president; J. E. Galvin, vice president and secretary; George S. Stage, treasurer. The product of the plant consists of a great variety of medium size castings, a large percentage of which are used in the automobile industry.

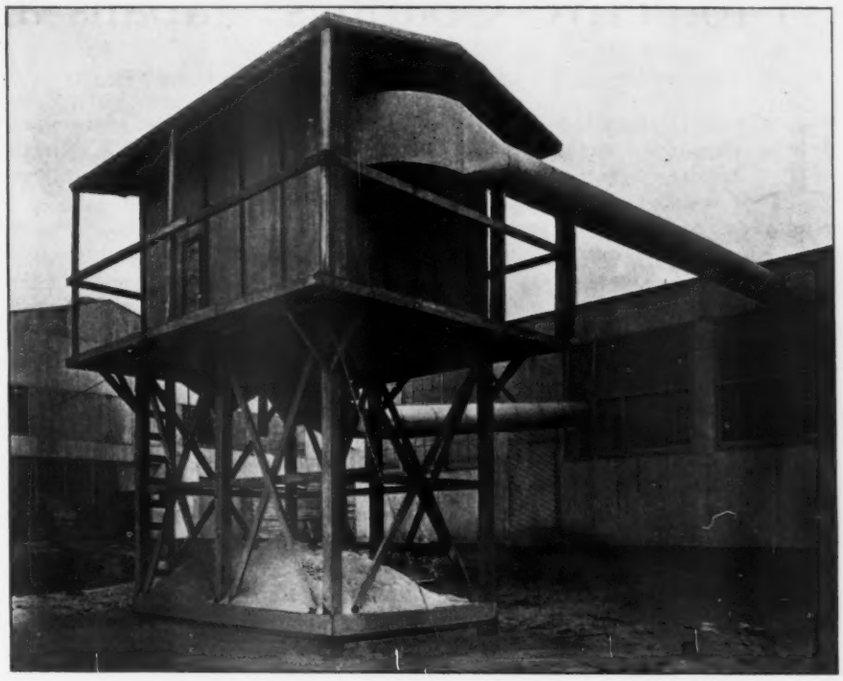

FIG. 9—DUST FROM THE SAND BLAST AND FROM THE TUMBLING BARRELS, GRINDERS, ETC., IS BLOWN TO DUST ARRESTERS OUTSIDE THE BUILDING

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The annual sales convention of the branch managers and salesmen of the Independent Pneumatic Tool Co., Chicago, was held in that city on Feb. 28 and March 1. The first day's meeting was held at the company's factory, Aurora, Ill., where the representatives were given an opportunity to inspect the manufacture and construction of the company's extensive line of pneumatic tools. The second day's meeting was held in the New Southern hotel, Chicago, for the discussion of sales policies.

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The Kirk Supply Co., Pittsburgh and Cleveland, has recently been appointed agent for the Canada Carbide Sales Co. A stock of carbide will be carried at Cleveland.

# Protective Coatings: Japans and Enamels---II

By E P Later

IN THE preceding article the composition and properties of ordinary lacquers were briefly considered. Useful as these preparations are, however, there are many purposes, for example, finishing automobiles and general metal parts which must withstand wear and exposure and need to be protected from corrosion, for which they are not well fitted. Recourse must be had in such cases to certain other finishing materials which are of wholly different composition and possess different qualities, known as japans and enamels. These, and particularly the baking japans, give a hard, rugged film which has excellent protective as well as decorative qualities and are indispensable in certain classes of work.

In general, black baking japans are made by combining linseed oil and asphalt, gilsonite, stearine pitch, coal tar pitch and similar substances at high temperatures. The resulting product is thinned with turpentine, benzine, or light mineral oils and when properly applied and baked at temperatures ranging from 200 to 450 degrees Fahr. will give a more or less thick coating which is quite hard, fairly impervious to moisture and of a high luster. The baking period, which varies from two to six hours or longer, and the temperature of baking depend on the composition of the japan. Dull and medium gloss japans are made by grinding the bright japan with lamp black or carbon black in a fine mill, or by the proper selection of the materials.

Japans may be applied in any one of several ways such as brushing, dipping and spraying, depending on the conditions. Thus, by the first method, the japan is applied by brushing, as in painting and is employed on parts which, because of their size or for any other reason, cannot be dipped or sprayed.

In dipping, the parts are immersed in a large tank of the japan, which is thinned with a suitable solvent to the proper consistency for the purpose, and then hung on some sort of a rack and allowed to drip, the surplus japan running back into the tank.

Tumbling the parts, which must necessarily be small and of such shape as to permit of it in a barrel with a small quantity of the japan is a convenient way of applying the finish and may sometimes be used to advantage.

*Spraying the Japan*

Applying finishing materials by a spray produced by leading them into an atomizer and then vaporizing them by a current of compressed air, is one of the latest and best methods of finishing metal work in particular, although it is coming into wide use in other lines. It is not so cheap as tumbling or dipping, wherein a much larger number of parts may be coated at one time, but it is applicable in many instances where these do not give the quality of finish desired. Uniformity, smoothness of coat and ease of control of the thickness are its chief advantages and it is used on a large variety of high grade work.

After the application of the japan by one of the foregoing methods, the parts generally are allowed to air-dry for a short time, then are loaded on trucks or placed directly in the oven and baked; and right here it may be said that improper baking is a prolific source of trouble for many finishers. These materials vary all of the way from the air-drying sort, that is, those which will become sufficiently hard for the conditions of service by simple exposure to the air, to those which require heat-treatment to a temperature of 300 to 400 degrees Fahr. to oxidize and harden them. Therefore, there is a wide range of baking temperatures and it is important to see that the proper control of these is obtained, otherwise the results will not be satisfactory. A properly baked japan film should be hard enough to withstand scratching with the finger nail, but should not be so brittle that it will flake and chip off when cut through with a knife or struck sharply. If the film is not baked the way it should be, for instance, at too low a temperature or for too short a period, it will be too soft and tender and may even be sticky or tacky. On the other hand, overbaking, by overexposure to too high a temperature manifests itself in a brittle, lifeless film which chips easily and has poor adhering qualities.

The advice of the maker of the japan should be obtained as to the proper temperature and time of baking and ordinarily this should be followed closely, but it may be remarked that in general, an increase of temperature means a shorter time of baking, so a good deal may sometimes be done to shorten the finishing time by heating the oven hotter and thus decreasing the baking period. Such changes should be made cautiously, however, and only after careful experiments have shown the proper conditions to be maintained and that the finish so produced is fully up to the standard.

It is apparent that a good oven, heated throughout as evenly and uniformly as possible, and provided with the proper facilities for ventilation and accurate determination of the temperature, is a necessity if good work is to be turned out regularly. The baking of a japan film involves two distinct processes; first, driving off all solvents and compounds which are volatile at the temperature employed and second, oxidation of the oils and possibly other substances in the film to a hard coating which is insoluble and resistant to wear. If the vaporized gases and vapors are not given a free opportunity to escape they tend to hinder the baking and may result in poor or spoiled work.

There are several types of ovens, differing largely in the mode of heating, such as by steam, generally high pres-

sure, electricity, gas and coke. Each has certain advantages and all are used to some extent, but the gas-fired ovens are very popular and find, perhaps, the widest use. Heating by means of steam coils is a convenient way of obtaining low to medium temperatures, but higher temperatures require the use of high pressure steam, which is harder both to produce and handle. If electricity is cheap it can be utilized satisfactorily for heating the oven, if the coils or heating units are properly planned and built; any temperature which would be required for the work can be produced and a close control maintained. The need of keeping a uniform temperature in all parts of the oven is a very real one, as otherwise some portions of the load will be overbaked and others not enough. In an electric oven the heating elements can be so placed as to eliminate this trouble almost, if not quite, entirely.

Heating the oven with coal or coke may be cheap enough, but it is rather unsatisfactory. Tending and regulating the fire involves a good deal of work, considerable time is needed to bring the oven up to the desired temperature and it is not an easy matter to keep it there, within reasonably close limits, and atmospheric conditions have much to do with the operation of the oven. Furthermore, the dust and ashes which cannot be completely done away with are detrimental to good work.

There are several well-designed gas ovens on the market and they afford a fairly cheap and convenient solution of the baking problem; they are arranged to give a good distribution of the heat, are easy to operate and permit of close control of the temperature at any desired point.

### *Repeated Coatings*

After the parts have been baked and allowed to cool, those which are to receive more than one coat of japan are usually smoothed down and all roughness removed by means of fine sandpaper, after which all dust is carefully brushed or blown off and the second coat applied and baked as before, this process being repeated the requisite number of times. In some classes of work the final coat is rubbed with pumice stone in water or otherwise treated to produce a higher grade finish.

A large variety of household and other articles, shovels, dustpans, etc., are finished with a very cheap grade of japan made by dissolving bituminous compounds in turpentine, benzine or similar solvents. These japans usually are applied by dipping, are often air-drying, although some are baked, and give a glossy brown or black finish which serves the purpose for which it is intended and frequently stands up surprisingly well. They would not, of course, be suitable for very high grade work, but are mentioned here as the metal finisher sometimes may be called upon to use them.

For many purposes, however, the foregoing class of materials is not suitable, as white or almost any other color may be required, so recourse is had in such cases to those materials known as japan-enamels or varnish-enamels, to distinguish them from the true enamels which are essentially fusible glasses and will be considered later.

### *Varnish-Enamels*

These varnish-enamels are produced by grinding one or more pigments in a suitable varnish vehicle, in a fine mill, about as in paint grinding. Varnish, however, is such an important and useful material and its nature and properties often so little understood that it will be worth while to review briefly the main points in its manufacture. The accomplishment of the desired result in the use of these materials is simply a matter of handling and applying them in the proper way.

The manufacture of ordinary oil varnish is a highly developed art in its finer details, but the broad principles are simple enough. The resins used in varnish making—kauri, copal, manila, pontianac, etc.—some of which were mentioned in the previous article, dealing with the manufacture of lacquers, are not soluble in linseed oil, but must be melted and heated to a high temperature before a satisfactory combination can be made. The process of varnish making, therefore, consists in melting a certain amount of the resins in a large copper kettle mounted on small wheels. This is placed over a coke fire, under a broad stack, and heated until the resins have melted and reached the proper degree of fluidity. During this heating various oils and volatile compounds are driven off so the gums will shrink from 10 to 25 per cent by weight.

Refined linseed oil, which has generally been heated or otherwise treated previously, is slowly added to the melted mass and thoroughly stirred; the cooking is then continued until the solution and combination of the materials is complete, a process which calls for much experience and skill. After being allowed to cool for a time, the mixture is thinned to the proper body with turpentine or light mineral oils and the varnish is then drawn off into large tanks and allowed to stand for months or even years, in order to settle and age.

A large variety of varnishes can be made, since any one of several gums or combinations of these may be used and the amount of oil added may vary widely. A given varnish may be entirely satisfactory for one purpose and practically useless for another; therefore, varnishes are, or should be, made up with due consideration of the purposes for which they are intended.

When different pigments are ground in a varnish a rather thick liquid is obtained, which gives a more or less glossy finish of any desired color. These varnish-enamels are practically air-drying if given enough time, but are almost always dried or baked at a gentle heat, generally not above 180 degrees Fahr. at the most, for a period varying from one to three or four hours. The degree of heat, and to some extent the length of time, depend on the color of the enamel and on the varnish base. The light and delicate colors usually darken for one reason or another very readily under the influence of heat so great care must be taken to keep all conditions well within the danger line or spoiled work will be the result. Of course, darkening is usually not so objectionable with the darker colors and it is often possible to use a higher temperature with these.

It can be noted that the maintenance of a steady, uniform temperature in all parts of the oven, with sufficient ventilation to remove quickly all products of evaporation or combustion and supply fresh air is of much more importance in the case of these enamels than with the black japans. It requires so little to disfigure or spoil work of this nature it is usually necessary to exercise every precaution if high grade work is to be produced, and this applies not only to the baking, but to the application as well. Thus, the parts must be entirely free from grease or dust and dirt; in the latter case streaks or a muddy effect will be produced, especially if the material is applied with a brush. Brushes and spraying machines must be thoroughly cleaned before using and, as in the case of lacquers, varnishes or any high grade finishes, the air of the finishing room must be kept as free from dust as possible and the parts should be allowed to dry only on a covered truck.

### *Consideration of True Enamels*

Color work of this sort generally receives more than one coat, so each is lightly sanded and smoothed down to remove all rough spots and provide a surface to which the next one can adhere, before the latter is applied.

Sometimes a final coat of clear varnish is given to protect a color coat or bring up the gloss, but the application and baking of this is about the same as given for the preceding coats.

The true enamels, which were mentioned briefly, are an entirely different class of materials from those which have been considered so far, being, in effect,

glasses. The ordinary metal finisher is not called on, as a general thing, to produce this kind of work, but those engaged in the finishing of jewelry and art goods usually have more or less of it to do and, further, since the enameled ware industry is a big one and is still growing, it is worth while to briefly discuss the process.

While the enamels are essentially glasses they are of somewhat different composition and properties than the ordinary material with which we are acquainted and may broadly be considered to be compounds of calcium, aluminum, potassium and sodium with silicon and boron. These elements may be derived from a mixture of calcite or fluorspar, sand or ground quartz, feldspar and clay, soda ash and borax. Naturally, enamels for different purposes have different compositions and various substances other than those given may be added; thus, manganese dioxide is employed in dark colored enamels, as an oxidizing agent, while cobalt oxide and other oxides and compounds find a wide use. Certain metals are introduced for the purpose of giving a desired color as, copper or chromium for green, uranium or titanium for yellow, manganese for violet or brown, cobalt for blue, tin oxide for white, etc.

There is almost an endless number of formulas for enamels and a good deal of secrecy is observed by the manufacturers regarding the materials and proportions of each used, although the general process of manufacture is the same, substantially, for most of these. After the materials are weighed they are well mixed and charged into a reverberatory furnace heated by gas or oil and melted down to a clear glass. When this is accomplished the molten mixture is run into water and thereby broken up into fine particles which are then ground in a mill to a powder which is usually suspended in water.

In applying the finish the thoroughly cleaned parts are dipped into this suspension or the finish is brushed or sprayed on and allowed to dry; then the parts are placed in a muffle or suitable furnace and heated to a temperature of 1,000 degrees Cent. or more. This intense heat fuses the particles of enamel into a hard, strong coating of glass. One or two additional coats, depending on the nature of the work, may then be given, each applied and burned as before.

The final result is a hard, glassy surface which is capable of withstanding severe wear and tear, is not easily affected by acids or alkalis and possesses considerable decorative merit.

# Melting Malleable Iron in Electric Furnace

AN EXCEEDINGLY interesting method of melting and refining malleable iron for castings has been developed by W. G. Kranz, vice president, The National Malleable Castings Co., Cleveland, involving the use of a primary melting furnace, such as a cupola or air furnace, together with a bessemer converter and an electric furnace. The details of the process are described in a patent issue to Mr. Kranz on Dec. 5, 1916, and assigned by him to The National Malleable Castings Co. This patent, No. 1,206,861, reads as follows:

"My invention relates to the treatment of iron intended to be made into castings; and is designed to overcome the difficulties resulting from the presence of relatively high carbon and also in some cases of relatively high manganese and silicon, but particularly of carbon, in the iron.

"In carrying out my invention, pig iron or scrap, or both, high in carbon, and which may contain appreciable percentages of manganese and silicon, are melted in any suitable furnace, such as a cupola, open hearth, or air furnace. A portion of the melted charge depending on the amount of carbon and other impurities to be removed is then tapped out of the furnace and transferred to a bessemer converter, in which the carbon, manganese and silicon are wholly or partially blown out. The treated metal, and the remainder of the charge direct from the furnace, are then poured into a ladle or other container with the result that the percentage of carbon (as well as the percentage of the manganese and silicon) in the complete charge is reduced to within desired limits, and may then be cast. If a further refinement is desired, the charge may be transferred to an electric or other suitable refining furnace, in which the refinement of the metal is completed.

"It may also be desirable to tap the metal in the first instance from a blast furnace, in which event a proper proportion of the metal is first introduced into and treated in a bessemer and the carbon and other substances reduced. The treated metal is then mingled with the remainder of the charge from the blast furnace either to be cast or to be further treated in a refining furnace.

"I have found that with a charge of iron containing 3.25 per cent of carbon very satisfactory results can be obtained by taking one-fifth of the charge, introducing it into a bessemer and reducing the carbon to 0.50 per cent or less by treatment therein, so that when the treated metal is mingled with the remainder of the charge the percentage of carbon in the whole is approximately 2.70 per cent. After further treatment in an electric furnace the metal thus refined is extremely well adapted for malleable castings, and can be produced at a very much lower cost and in much less time than is the case when the reduction of the carbon is effected in either the melting furnace or in the electric furnace. If it is desired to produce gray iron castings, suitable additions such as manganese or silicon may be made in the vessel to which it has been transferred, and the charge may then be cast.

"The advantages of my invention will be apparent to those skilled in the making of iron castings, since the troubles arising from high percentages of carbon and in some instances from high percentages of manganese and silicon, are practically eliminated, and iron containing excesses of such materials is rendered commercially available for malleableizing and other purposes at a low cost and with a considerable saving in the time required for its conversion into castings. By the use of my invention it will be seen that the carbon and other substances may be reduced and equalized in any proportions depending on the character of the iron which it is desired to produce. It is, however, not usually desirable to reduce the carbon below 1.50 per cent; and while for certain purposes the treated metal may contain any per cent below the carbon content of the untreated metal, in most instances it is desirable to reduce the carbon to below 3 per cent.

"The terms and expressions which I have employed are used as terms of description and not of limitations, and I have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described, or portions thereof, but recognize that various modifications in the method as described and in the apparatus as used are possible within the scope of the invention claimed."

The National Malleable Castings Co. is constructing a new plant in Cleveland in which apparatus for making malleable castings substantially according to the foregoing process is being installed.

The equipment, it is understood, will include two 12-ton electric furnaces of the heroult arc type, bessemer converters, cupolas, traveling cranes, machine tools, etc. The building, which is irregularly shaped, will be approximately 575 x 725 feet. The plant occupies a site of 32 acres, purchased a few years ago.

# The Manufacture of Manganese Steel Castings

*A Discussion of the Difficulties Encountered in Making Alloy Castings —The Application of Manganese Steel to Various Kinds of Work*

By W S McKee

ALTHOUGH the steel foundry industry has made tremendous strides in the past decade, the difficulties surrounding the manufacture of steel castings are scarcely less embarrassing at present than they were 10 years ago. As fast as the problems standing in the pathway of progress are solved and removed, new perplexities arise owing to the enlargement of the field of operations. The growth of the industry has led to specialization and at present there are several large steel foundries in the United States and abroad that concentrate their efforts on the production of high manganese castings. On account of its peculiar properties including remarkable resistance to abrasive action, manganese steel is used for a great variety of industrial purposes and the shops manufacturing this material in the United States now have a combined capacity of approximately 70,000 tons per year.

FIG. 1 — MICROSTRUCTURE OF CAST MANGANESE STEEL UNTREATED, MAGNIFIED 100 DIAMETERS

Strange to say, however, the difficulties surrounding the manufacture of manganese steel castings do not seem to be as fully appreciated as those connected with the production of ordinary carbon-steel castings, possibly because they have not been as widely discussed. As a matter of fact, the manganese steel foundryman finds himself confronted with all the problems of the ordinary steel foundryman, plus a host of special complications arising from the peculiar physical and chemical characteristics of the material with which he is working. In order to achieve success it is necessary to have special experience all along the line, particularly with reference to melting and mixing the metals and heat-treating the castings. It is for the purpose of pointing out and discussing some of the peculiar problems of the manganese steel foundrymen that this article has been written.

Manganese steel was developed originally in England, largely through the efforts of Sir Robert Hadfield. It has been manufactured on a commercial basis for nearly 26 years. The first manganese steel castings made in the United States were turned out in 1892. Originally it was considered impossible to make manganese castings successfully weighing over a few hundred pounds, but at the present time large rolling mill pinions, crusher heads and similar castings weighing up to 30,000 pounds each are being produced regularly and it does not appear that the limit of weight has been reached by a considerable margin.

### *A Great Variety of Uses*

Manganese steel castings are used for a great variety of purposes, including parts for asphalt presses, ball mills, brick and tile machinery, cement kilns, Chilean mills, clay mills, coal breaking machinery, coal mining machinery, concrete mixers, copper converters, traveling cranes, crushers, dredges, gears, grab buckets, steam shovels, lifting magnets, rolling mill machinery, stamp mills, etc. Manganese steel also is employed for the manufacture of safes, railway frogs and crossings, foundry tumbling barrels, etc.

As manufactured at present, manganese steel is similar in analysis to ordinary converter metal except that it is high in carbon and unusually high in manganese. In ordinary commercial castings the proportions of the latter metal range from 11 to 13½ per cent. This combination of elements gives the finished castings certain distinctive metallographic and physical qualities, which will be detailed later in this article. From one standpoint, manganese steel is similar to malleable iron in that the casting as it comes from the sand is almost glass hard and very brittle. It must be made ductile by an annealing or heat-treating process. The heat treatment is a very essential part of the process, and must be properly manipulated to insure satisfactory results.

The necessity for heat treatment limits the thickness of section which it is possible to cast successfully with manganese steel. Originally the castings were made with comparatively thin sections, but researches carried on during the past few years by prominent manufacturers have resulted in a gradual increase in the thickness of section that it is possible to treat successfully, until at present castings with walls up to 5½ inches in thickness are handled satisfactorily. Heavy castings are cored out to a minimum thickness of 5½ inches. This not only serves to eliminate the internal stresses which invariably are set up in a very thick casting, but also reduces the weight and inertia of the piece, an important consideration if the casting is a moving part in a machine. At the same time, the maximum annealing thickness of 5½ inches is sufficient to permit the use of manganese steel for the heaviest classes of machinery. It is evident from the foregoing, that although manganese steel is made in a converter and cast in sand molds, the process is by no means a simple one. Unusual experience and ability are required if successful results are to be obtained.

FIG. 2 — MICROSTRUCTURE OF CAST MANGANESE STEEL PROPERLY HEATED, MAGNIFIED 100 DIAMETERS

The early papers of Sir Robert Hadfield mentioned tensile tests of specimens of manganese steel showing an

A paper presented at the September, 1916, meeting of the American Foundrymen's Association, Cleveland. The author of this paper, is vice president of the American Manganese Steel Co., Chicago.

ultimate strength of approximately 100,000 pounds per square inch with elongations as high as 40 per cent. In some few instances an ultimate strength of 150,000 pounds per square inch is mentioned by Mr. Hadfield. That the physical characteristics of manganese steel are superior to many high grade steels is indicated by the following figures averaged from a series of 19 tests of manganese steel made by Robert

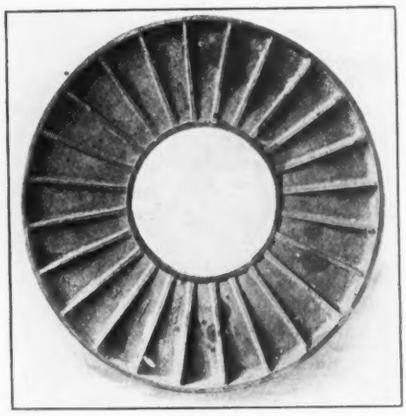

FIG. 3—COIL SHIELD FOR LIFTING MAGNET

W. Hunt & Co., Chicago. The figures are as follows: Elastic limit, 53,396 pounds per square inch; tensile strength, 108,460 pounds per square inch; elongation in 2 inches, 33.71 per cent; reduction of area, 38.56 per cent.

Manganese steel does not owe its wear resisting qualities to its hardness. When subjected to the Brinell test, it shows an average hardness number of about 200. The extreme outer fibre

FIG. 4—LARGE MANGANESE STEEL CUTTER HEAD

of the treated steel shows a slightly lower hardness number than at a depth of about ⅛-inch. From the latter point the hardness remains constant to the core of the casting. The lowering of the hardness at the surface is due to the oxidation of the carbon which forms on the surface during the heat treatment. The toughness of the material is due to its great molecular cohesion which causes the particles to flow rather than to tear off. When tested with a scleroscope, manganese steel shows a hardness of from 40 to 50. The specific heat ranges from 0.145 at ordinary temperature to about 0.20 at 1,200 degrees Cent. Between ordinary atmospheric temperatures and 600 degrees Cent., the heat conductivity appears to be about one-third that of low carbon steel. The specific gravity of manganese steel ingots is nearly the same as the result obtained by the usual method of determining specific gravity with a chemical balance, using a small specimen of cast steel. The rolled steel is slightly heavier than the cast material.

### *Peculiar Electrical Properties*

The electrical resistance of manganese steel is approximately 3.4 times the resistance of ordinary bessemer steel. At temperatures between 100 and 600 degrees Cent. the electrical resistance is said to remain practically constant. Manganese steel is non-magnetic and advantage is taken of this property in the use of this material for shields or bottom plates for lifting magnets, such as are extensively employed in foundries. The shrinkage of manganese steel is excessive, amounting to 5/16-inch per foot as against 3/16-inch to ¼-inch in ordinary steel foundry practice. The high shrinkage creates a number of foundry problems which will be discussed in some detail later. Cast manganese steel has a chemical composition as shown in the following table:

CHEMICAL ANALYSIS OF MANGANESE STEEL.

| | Per cent |
|---|---|
| Carbon | 1.25 |
| Silicon | 0.30 |
| Manganese | 12.50 |
| Sulphur, less than | 0.02 |
| Phosphorus, about | 0.08 |

The distinctive characteristics of manganese steel are clearly delineated by the microscope. It is well known that manganese is present in all ordinary steel, but the metal does not become austenitic until about 6 per cent manganese and 0.80 per cent carbon are introduced. Commercial manganese steel generally contains from 11 to 13½ per cent manganese and from 1.00 to 1.30 per cent carbon.

### *Metallographic Explanation of Characteristics*

In the cast state the metal is composed principally of austenite and free cementite, austenite being a solution of iron, manganese and carbide of iron and mangenese, while free cementite is composed of the carbide of iron and manganese which remain undissolved. Free cementite is very hard and brittle and therefore manganese steel is also very brittle in the cast condition. However, upon receiving a proper heat treatment all of the free cementite is dissolved forming austenite which is known to be very ductile and to present a high resistance to wear. We thus have a metallographic explanation of the chief characteristics of manganese steel. In order to obtain the austenitic structure it is necessary that the steel be given a correct treatment. Microscopic examination reveals the fact that if the steel is heated to a proper temperature and quenched in water, it is composed entirely of austenite. By the aid of the microscope, therefore, the proper structure can be determined and together with physical tests and chemical analysis most excellent results are obtained.

The accompanying microphotographs, Fig. 1 and Fig. 2, show the structures of manganese steel as cast and after treatment, magnified 100 diameters. Fig. 1 shows the structure of manganese steel in the cast condition. Fig. 2 shows the same steel heated to a temperature of 1,800 degrees Fahr. and quenched in water. It will be noted that since the heat treatment all of the free cementite has disappeared leaving a purely austenitic structure. If the steel is again heated to over 700 degrees Fahr. the pure austenitic structure

FIG. 5—EARLY DESIGN OF DREDGE BUCKET SHOWING SHARP CORNERS IN BACK EYE

is destroyed, seriously injuring the quality of the metal. It, therefore, is imperative that manganese steel should not be heated to a temperature exceeding 700 degrees Fahr. after leaving the foundry where it was manufactured.

Owing to shrinkage difficulties and to the problems connected with annealing, it is necessary, in order to achieve success in the manufacture of manganese steel castings, to start with the design of the parts. A few simple changes in design may spell the difference between success and failure in the foundry. It is necessary for the designer, however, to have a thorough knowledge of the peculiarities of the metal. The importance of correct design is very clearly indicated by the dredge buckets shown in Figs. 5 and 6. The original type of bucket is shown in Fig. 5 and the improved design in Fig. 6. In Fig. 5 it will be noted that there are two square corners in the back eye. In this design the bushing, with which the eye is fitted, bears on

the shoulders created by the two sharp corners previously mentioned. Although these corners were provided with a small fillet it was found extremely difficult to insure perfectly sound metal at this point. As a result, the bucket was apt to fail at one of the points of greatest stress. In the improved design shown in Fig. 6 it will be noted that the two square corners have been entirely eliminated resulting in a much more satisfactory job from a foundryman's standpoint. Fig. 6 not only shows the new form of the back eye but also illustrates the bushing with which the eye is fitted. Generally speaking it is more necessary to avoid an abrupt change in section and sharp corners when making manganese steel than when turning out ordinary low carbon steel castings.

It is necessary that the pattern be provided with the proper shrinkage allowances and for this reason many manganese steel foundrymen prefer to make their own patterns from original drawings supplied by their customers. When patterns are furnished they frequently have to be rebuilt in order to

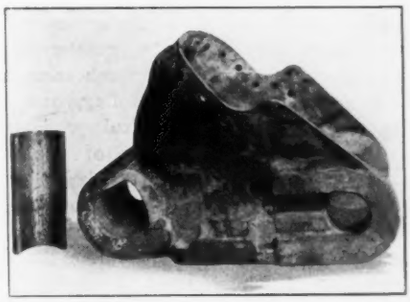

FIG. 6—PRESENT DESIGN OF DREDGE BUCKET WITH CORNERS IN BACK EYE ELIMINATED

obtain satisfactory results. The allowances for shrinkage are not confined simply to the dimensions of the pattern, but also include the distribution of the metal in the casting. At times it is necessary to add metal to a casting temporarily to withstand shrinkage strains; such additions of metal are removed in the machine shop by grinding before the casting is shipped. In handling work of this character, unusual skill is necessary in order to properly allow for shrinkage stresses. While a majority of the patterns used in manganese steel foundries are made of wood, it has been found advantageous to use metal where great durability is required, as in ordinary practice. A complete manganese steel casting plant, therefore, should include a properly equipped pattern shop provided with band saws, circular saws, woodworking lathes, and boring and mortising machines, together with other equipment for the rapid and economical production of the various kinds of patterns.

The molding floor of a typical large manganese steel foundry is shown in Fig. 9. It will be observed that the crane equipment is extensive including heavy electric traveling cranes which span the entire floor, supplemented by wall cranes. In making molds it has been found that ordinary molding sand and clay binders are unsatisfactory on account of the cutting action of the molten metal. Sands with a high percentage of silica are used and most of the molds are oven dried. Special facing mixtures are required owing to the crushing effect of the shrinking manganese steel. An open facing which will yield readily is necessary, but at the same time sufficient skin hardness to prevent the mold from being washed away is required. Similar difficulties are encountered in providing proper core sand mixtures. These mixtures must be free venting; they must have sufficient strength to stand up properly under the destructive action of the molten metal and at the same time the core must yield readily when the casting commences to shrink. The larger manufacturers of manganese steel have conducted extensive experiments which have enabled them to determine the proper mixtures for facings and core sand and to develop standard formulas.

*How the Metal is Melted*

For melting the metal standard side blow converters have been found satisfatcory. At the Chicago Heights plant of the American Manganese Steel Co. two cupolas are provided for the primary melting of the metal and four 3-ton converters are installed. The cupolas are situated in a mezzanine floor behind the converters and are so arranged that the metal may be drained directly from the cupola spouts into the converters. The ladle and crane equipment is similar to that found in the average steel foundry handling heavy work.

Manganese steel is a special converter metal to which a quantity of ferro-manganese is added in the ladle. Standard 80 per cent ferro-manganese is employed and it is necessary to provide suitable facilities for melting this material. For this purpose either crucibles or specially designed reverberatory furnaces may be employed. If the latter method is used, considerable experience is required to design the furnace properly and to operate it successfully. The reverberatory furnace, however, has certain advantages over the crucible method, inasmuch as under proper conditions the labor cost is much less. The working conditions in the furnace room also are less severe and the cost of crucibles, no small item at the present time, is eliminated.

The melted alloy is placed in the bottom of the ladle and the steel from the converter is poured in on top, enough ferro-manganese being used so that the castings will show about 12½ per cent manganese when analyzed. This is an average figure; the exact quantity of manganese varies somewhat with the nature of the work. The manganese acts as a strong scavenger, removing the gases and impurities from the metal, leaving it condensed and

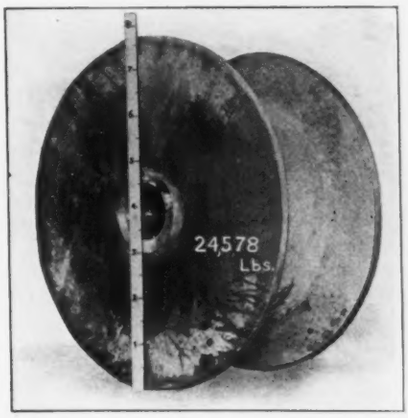


FIG. 7—MANGANESE STEEL DREDGE TUMBLER WEIGHING 24,578 POUNDS

homogeneous. The production of slag is excessive and before the molds are poured the ladles are allowed to stand for a time in order to permit the alloy to perform its function and also to skim off the slag. The raw materials used in the production of the converter metal include low-phosphorus pig iron and selected steel scrap, similar to those used in the ordinary bessemer steel

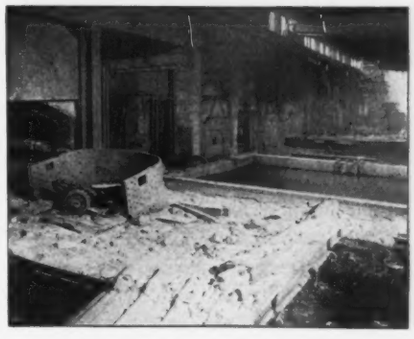

FIG. 8 — HEAT TREATING FURNACES WITH TANKS FOR QUENCHING CASTINGS

foundry. The same careful selection is necessary to insure uniformity in the finished product. The metal is handled and poured while very hot.

As previously mentioned, when the castings come from the sand they are glass hard and before they are suitable for use they must be annealed. For this purpose furnaces of the proper size in which the temperature may be readily controled are necessary, together with quenching tanks and suitable crane

equipment for handling the hot castings. The annealing furnaces are of the ordinary open-flue type. Usually they are provided with cars on which the castings are placed for the heat-treating process. It is essential that as little time as possible elapse between the moment when the furnace door is opened and that when the casting is immersed in the quenching tank. It is, therefore, desirable to locate the tanks directly in front of the annealing furnaces as shown in Fig. 8.

In discussing the heat treatment of manganese steel, W. S. Potter in a paper presented before the Western Society of Engineers, at Chicago, Feb. 17, 1909, makes the following interesting statements:

"Upward of 75 years ago men in Sheffield, Eng., understood that steel

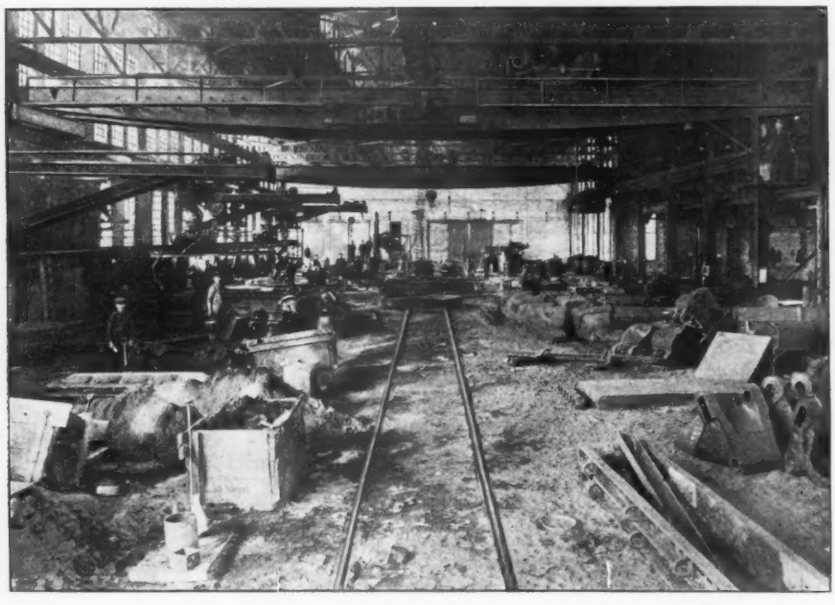

FIG. 9—GENERAL VIEW OF MOLDING FLOOR OF TYPICAL MANGANESE STEEL FOUNDRY—NOTE EXTENSIVE CRANE EQUIPMENT

containing moderate additions of manganese had certain properties which could be described as those of carbon steel, and that steels containing a higher percentage than 5 per cent or 5½ per cent were very weak and brittle.

"Some 30 years ago the Hadfields, father and son, or their associates, found, and the son advertised, the fact that castings and forgings containing the higher percentage of manganese, after heating to a high temperature and quenching with water, were very strong and tough and that the treated steel had remarkable resistance to abrasive wear. The proportion of manganese mentioned as suitable for track-work castings, in Hadfield's early patents is 11 per cent. No heat treatment was mentioned in the early papers, but later a treatment was announced and consisted in heating the castings at first slowly and then rapidly to 800 degrees, 900 degrees, or 1,000 degrees Cent., and immediately quenching in water. No theory covering the necessity of this reheating and quenching was given.

"Manganese steel of ordinary composition poured in a layer about ¼-inch to ½-inch thick in a chill mold will, when cold, bend double, and has all the usual toughness of reheated and quenched manganese steel. Castings from the same ladle of steel poured in sand molds have a toughness approximating the toughness of the reheated and quenched metal in inverse proportion to the thickness of the sand cast section. For example, a sand-cast section ½-inch thick will usually bend from 45 degrees to 90 degrees before it breaks by cold bending. A section 2 inches thick usually breaks in cold bending before it is deflected as much as 20 degrees. The thinner section is whiter and has smaller crystals than the heavy sand-cast section, and the chill-cast section is still whiter and has still smaller crystals than the thin sand-cast section. If the three specimens are heated to 1,000 degrees Cent. and quenched in water they will exhibit in each case a very remarkable and practically equal degree of toughness. In all these cases the steel has practically the same hardness. The chill-cast specimen, before reheating, is the hardest; the sand-cast specimens are the softest. If the specimens are now heated to 700 degrees Cent., or even a little lower temperature, held for, say one-half hour at this temperature, and cooled slowly to ordinary temperature and broken, they are surprisingly weak, and as a rule, bend but slightly before breaking. The crystals are very large and it is obvious that no strong cementing materials are present to bond the crystals. A section 3 inches thick cooled slowly from the heat of casting, and put under a drop weight will break about as readily as an equal thickness of a fair quality of gray iron and will frequently show crystals with a mirror surface as large as 1¼ x 1 inch. For the most part such a section so treated and broken will show crystals about ¼-inch to ⅜-inch on a side. A specimen heated to above 700 degrees Cent. and cooled slowly to below 600 degrees Cent., is very weak. If this specimen is reheated to 700 degrees Cent., and quenched in water only, a slight increase in toughness is noted. The crystals are still apparently as large as ever. The bond between the crystals is almost as weak as before, and yet from the other tests it is clear that the steel crystalizes or re-crystalizes considerably below 700 degrees Cent.

*Analysis by Color Tests*

"Comparing this steel with a carbon steel it is obvious that the cementing materials are not taken into solution at as low a heat in the manganese steel as in the carbon steel. In the carbon steel, the size of crystals, strength, toughness, etc., may be redetermined any number of times by reheating to 700 degrees Cent. and cooling, and as is well known, the physical properties are governed by the rate of cooling. The manganese steel after being put in a weak condition due to slow cooling from 700 degrees or above is only put in a condition of maximum toughness by reheating to a much higher temperature and then cooling rapidly enough to prevent either mechanical or chemical separation. A comparison of color carbon tests with determinations of total carbon by combustion, shows that the slow-cooled steel has a much smaller amount of carbon in the condition which permits of the determination of carbon by color than the manganese steel which has been rapidly cooled. The highest color result is obtained from the thin chill-cast section, the next highest from a specimen heated for a short time only and quenched in water. The lowest carbon result, by color test, is found in the specimen which has been heated to a high temperature, maintained at this temperature for some time and cooled very slowly. The chill-cast specimen showing by total carbon determination 110 points carbon, by color test may show 105 to 108 points. The specimen annealed at a high heat will give color results ranging from 0.60 to 0.95 per cent, depending upon the time to which the specimen was exposed to the highest temperature, the rate of cooling, and the percentages of manganese and silicon that are present in the metal.

"As might be anticipated from the general knowledge pertaining to the art of 'black heart' malleable iron manufacture, the percentage of silicon plays a very important part in the decomposition of carbides of iron and manganese in manganese steel. Manganese steel is readily burned when heated, and this burning is more difficult to avoid as the temperature increases. For this reason it is usual to heat for quenching only to a point sufficiently high to give the characteristic toughness in the quenched metal. If castings or other finished shapes are reheated for toughening to a high temperature they are apt to be very generally affected with deep cracks. To avoid burning and cracking the reheating is generally stopped at about 1,000 degrees Cent."

In operating the annealing ovens or furnaces it is necessary to heat the castings up slowly so as not to create expansion strains which will cause cracks. If the castings are heated rapidly the outside, of course, heats faster than the core, resulting in internal stresses of a serious nature. After the proper annealing temperature is reached, from 1,600 to 2,200 degrees Fahr., the castings must be given a soaking heat for several hours in order to bring the molecules into a state of equilibrium. The time required for this operation varies from 4 to 24 hours depending on the size and character of the casting. As previously stated, the thickness of the metal which can be successfully annealed has gradually been increased until now castings with walls 5½ inches thick are handled without any great difficulty. It is advisable to have the water in the quenching tanks as cold as possible in order to cool the castings quickly, before there is any time for internal structural changes. The men drawing the castings from the annealing furnaces must be protected from the heat with special clothing and helmets. Respirators also are desirable owing to the noxious gases emitted from the furnace when the door is opened.

### *Castings Not Easily Cleaned*

The proper cleaning of manganese steel castings presents many problems in itself. Very little sand adheres after the casting comes from the quenching bath. The metal is so tough, however, that practically all of the trimming operations must be conducted by grinding. Extensive portable, electrically-driven grinding equipment is necessary for this purpose. A general view of a modern manganese steel foundry grinding and cleaning room is shown in Fig. 10. It will be noticed that a heavy investment is required in order to properly equip this portion of the plant.

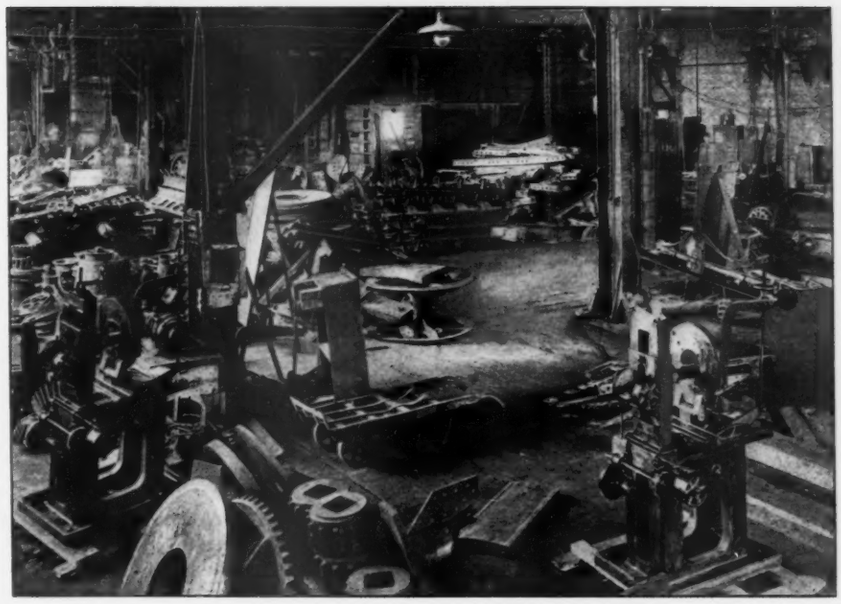

FIG. 10—GRINDING ROOM IN A LARGE MANGANESE STEEL FOUNDRY

Most manufacturers of manganese steel castings have found it advisable to establish extensive machine shops in connection with their plants. If the castings are to be finished in any way, special equipment is necessary. Ordinary machining methods are unsuccessful and grinding must be resorted to. Holes, more than ¼-inch in diameter, are cored out of the castings and ground to size with special wheels. When it is necessary to drill smaller holes or to cut threads soft steel or wrought iron inserts are set in the molds at the desired points like chaplets and the metal is cast around them. Incidentally this adds to the difficulties of the foundryman. Sometimes bushings are set in the hubs of gear wheels when it is desired to machine them by ordinary methods. Liberal allowances of metal are made for grinding in order to minimize the danger of spoiling the work in the machine shop.

It is necessary for the machine shop foreman to exercise his judgment continually; coarse wheels and heavy cuts are used so that the metal is removed rapidly, although by no means as easily as would be the case were it possible to employ ordinary cutting tools.

Some mention already has been

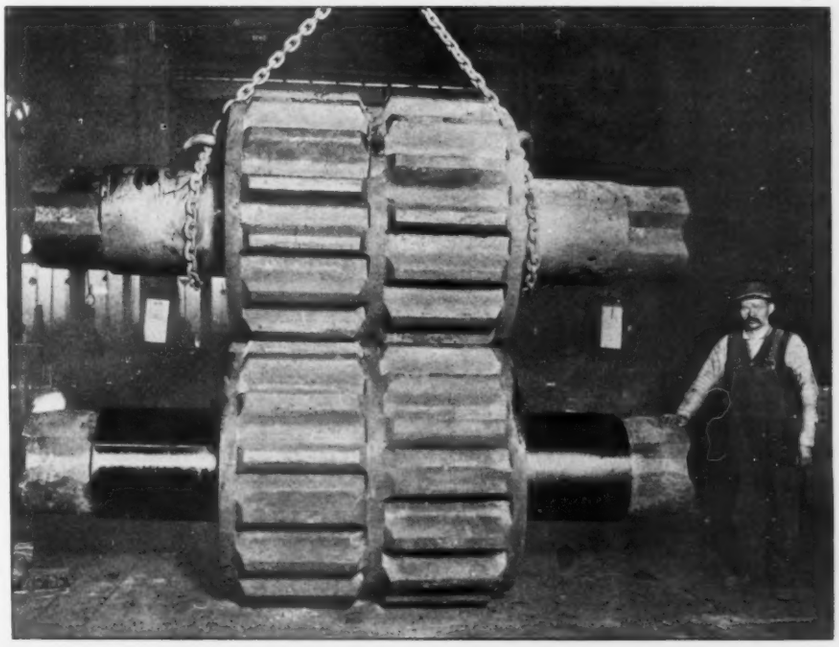

FIG. 11—HEAVY 52-INCH MANGANESE STEEL ROLLING MILL PINIONS

made of the purposes for which manganese steel is used. In the foundry, manganese steel is used for the linings for tumbling mills as well as for gears, crane wheels, elevator buckets, grab buckets, lifting magnet shields, etc. This material is particularly desirable for lining tumbling mills owing to its extreme resistance to abrasion. Where loads are heavy, manganese steel is extensively employed for gears and for the past three or four years it has been possible to produce manganese steel spur gears with the teeth ground theoretically correct. Ground gears now can be provided up to 44 inches pitch diameter with a 10-inch width of face. Many ordinary steel gears are cut with a range cutter which does not leave the rolling contact theoretically correct, whereas in grinding manganese steel gears a trimming arrangement is placed on the grinder for the purpose of dressing the emery wheel to the proper contour of the tooth face, so that when the mating gears are meshed each tooth is provided with a perfect contour on which to roll. After two years continuous service, the wear on a set of heavy high-speed manganese nest gears recently was measured. These gears had a 10-inch face and when new, the tooth measurement at the pitch line was 0.684-inch. At the conclusion of the two years' service, the tooth measured 0.601-inch. These gears are still in service after having more than earned their original cost and barring accidents they should be good for many years to come. The total wear was less than 0.1-inch.

Manganese steel has advantages for crane wheels where uniform diameters must be maintained on the drives to insure straight alignment in travel. A microscopic examination of a manganese steel wheel under load will show a flat spot instead of a line contact as in the case of hard metal wheels. Manganese steel under these conditions is springy and recoils as the load is released. About 30,000 pounds always has been considered a safe working load on chilled iron wheels for this purpose. Manganese steel crane wheels, however, are in successful use with rolling loads of 90,000 pounds per wheel.

Manganese steel also is extensively employed in the manufacture of rolling mill machinery. It has been found particularly suitable for the pinions on heavy roughing and blooming mills. A set of typical rolling mill pinions made of cast manganese steel are shown in Fig. 11. These pinions are cored out to a maximum thickness of 5½ inches, which decreases their inertia. Many other machine parts around steel mills are now being made of manganese steel including pipe drawing balls, chafing plates, sprockets, cams, draw chains, unloader chains, conveyor chains and buckets, screens, crusher castings, etc. It may be easily appreciated that the successful production of manganese steel castings involves a wide experience.

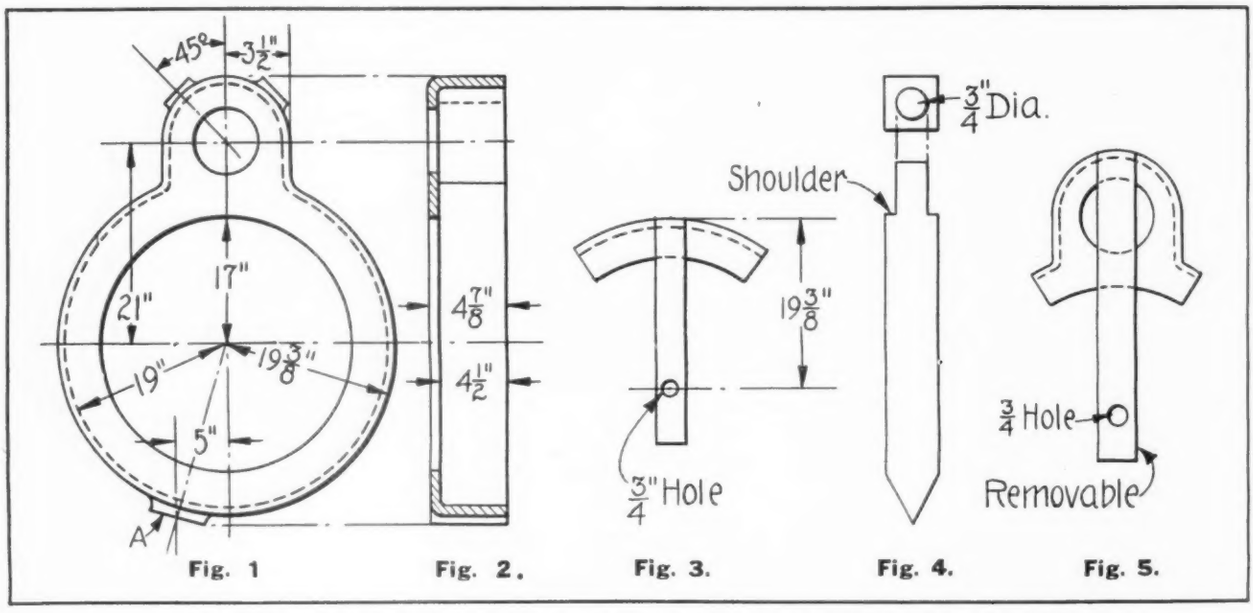


Fig. 1 Fig. 2. Fig. 3. Fig. 4. Fig. 5.

PLAN OF GEAR COVER CASTING AND DETAILS OF SWEEP FOR MAKING THE MOLD

## A Quick Method of Making a Gear Cover Casting

*By E. W. Wallbank*

A short time ago the writer was given a sketch for a gear cover with instructions to secure a casting as quickly and cheaply as possible. As will be seen in Fig. 1, the cover was 38¾ inches in diameter with the pinion cover cast onto it. First a piece was made exactly the shape and size of the pinion cover, with a location strip screwed on it temporarily. A ¾-inch hole was bored through this strip 21 inches from the center of the hole in the pinion cover, as shown in Fig. 5.

A piece was next made as shown in Fig. 3, with a location strip screwed permanently onto it. A ¾-inch hole was bored through this strip 19⅜ inches from the outer periphery. Next a center post, Fig. 4, was planed, and turned to ¾-inch in diameter for about 1 inch from the end. This allowed the ¾-inch holes bored in the location strips to fit snugly over it.

A bed was swept up in the foundry floor and the center post, Fig. 4, was driven down until the shoulder was 4⅞ inches from the bottom of the bed. The piece shown in Fig. 5 was located level and rammed up, after which the location strip was removed and the sweep shown in Fig. 3 placed in position and rammed up in sections until a complete circle was made. A center line was drawn through the mold with the aid of a center on the pinion cover pattern and the lathe center of the center post. The loose piece A was then bedded in at the proper place.

These sweeps were completed in less than 3½ hours and the lumber required was taken from the scrap box. The casting was poured the next day and was perfect in every respect.

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The Damascus Bronze Co., Pittsburgh, has purchased additional property, 75 x 100 feet, adjoining the site of its plant.

# The Fundamental Principles of Plate Mounting

*Methods of Determining the Position of Patterns in Various Kinds of Work—Use of Metal Patterns and Plates for Permanent Mounting*

By R R Clarke

AT THE outset we will state that we advance no claims whatever of offering something entirely new in principle or altogether original in conception. Time is comparatively recent when the idea and possibilities of mounting patterns from a mold was new to us, though we have since learned of some few foundries in which the basic principles were recognized before. At present it is doubtless new to others, for we know of foundries where its advantage is not yet in evidence. The object of our article must, therefore, become a desire to afford the idea a wider range of publicity and yield its advantage a large field of usefulness. To accord the plan and execution of a simple method of plate mounting an intelligent discussion and point out its advantages is an end as fair as we can hope to attain, nor do we aspire to any other.

A brief explanation of a few terms necessary to the discussion may be of value and we herewith submit it.

*Points* are determining factors of position and strictly speaking, have position only.

*Mechanical points* are those located and indicated by actual measurement. They have more or less of dimension and vary in correctness of relative position with the exactness of the measurement and the efficiency of the instrument.

*Geometric points* are those located through abstract calculation. They have strictly position only, are infinitely small and absolutely correct in relative position.

The older method of plate depends in every detail on measurement while in the method under discussion this is true in one detail only. In all other instances the coincidence of position falls under the unerring control of mathematical accuracy.

This simple method derives its advantage chiefly from its simplicity of execution. Given the patterns and plates, any molder can mount those of more common type in less than one hour's time, and that with a degree of coinciding exactness which is not always obtained by measurement. In the complex all positions are measured from lines or points having fixed and identical relative position to the pin holes in cope and drag plate. Thus every measurement admits the possibility of a shift.

The simple method depends on two points in the flask plane of the plate to find all lines of coincidence in the pattern field of both cope and drag In the drag plate these points are the centers of the flask pin holes; in the cope plate they are the identical points of coincidence which constitute the centers of the plate pin socket hole. It might be noted here that the centers of these holes approximate the invisible geometric point. Thus the only mechanical precaution in the simple method is that which insures in all plates strict uniformity and exact coincidence of flask pin holes. Any machine shop, at small cost, can rig a jig for this purpose. The skill and equipment essential to results in the complex are sorely missing in many foundries, while the expense of getting it done elsewhere makes first cost a serious consideration. In the simple the cost is little more than that of the plate and the patterns. Using pattern plates drilled and pinned to neatly identical changeable flasks, the location of all coinciding pattern positions in similar plates is governed by the following principle:

*Determining the Pattern Position*

The pattern position in the plane of the mold will indicate the pattern position in the plane of the plate when the plate is applied in pin-hole position to the mold. This principle is but an illustration of the general truth that two points determine the position of all points in the connected lines of a plane. Evidently the only thing to accomplish in the simple method is to catch the pattern on the plate where it is in the mold when the plate is applied in pin-hole position to the mold, and hold it there.

This catching-the-pattern feature admits a wide range for variation in method and affords excellent opportunity for comparison of ideas. One essential departure from the complex in the simple method is that the flask, pins and pin holes must lie within the bounding lines of the plate and not outside of them on the machine.

Most machines can be made or cut out to accommodate this feature which is really an advantage in that it does away with dowel pins and the possibility of a shift therefrom.

In considering those methods for the efficiency of which the author can testify, their individual features suggest the following order:

1—Patterns of level parting lines without stripping plates.
  A—Mounting the individual pattern.
    a—On the same plate.
      1—Temporarily.
      2—Permanently.
    b—On separate plates.
      1—Temporarily.
      2—Permanently.
  B—Getting the mounted pattern from the sand impression of the individual pattern.
    1—On the same plate.
    2—On separate plates.
2—Mounting patterns of depressed parting lines without stripping plates.
  A—By casting or cutting-out the locality of depression in the plate.
  B—By using a skeleton plate.
3—Mounting patterns with stripping plates.

In mounting the level-parting pattern direct on the same plate temporarily, both the pattern and plate can be made of wood, though in general, wood plates are not to be recommended. At the pin-hole position flanged bushings, neatly fitting the flask pins can be inserted. Both sides of the plates should be planed and sand-papered uniformly smooth and level. Long iron pins turned to neatly fit the flask and slightly full in the center can be inserted in the pin-holes of the plate. With this preparatory equipment observe the following:

Use plate for follow-board with flask in pin-hole position, arrange patterns, tamp drag solid, roll-over, take plate off, add cope half of pattern; use another drag with removable pins for cope of mold. Tamp solid, being careful to retain level sand parting surface; lift cope off, draw cope patterns, take pattern pins out or drive them back, replace patterns in cope mold. Apply medium touch of good shellac to evenly spaced sections of each half pattern-cope and drag. Set plate back in pin hole

position on drag half, hold plate firmly to flask and roll-over; set drag with plate attached in pin hole position over cope, clamp or weight firmly, allow shellac time to dry to good pattern-retaining consistency; lift cope half of mold from plate and roll-over carefully. Lift drag half of mold from plate and pattern is mounted. Retention of position can be further secured by tacking pattern to plate with small brads. In all cases an identical relative position should be transcribed from the mold on the plate to avoid reverse position in assembling the molds made from the plate.

*Permanent Mountings*

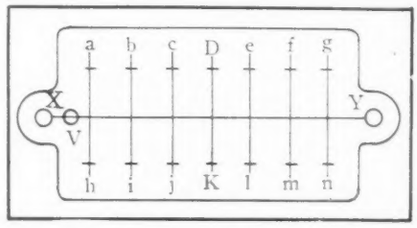
In mounting for permanency, metal patterns and plates should be used though wood patterns are sometimes permissable. The process is similar to that used in temporary instances except the means of securing the pattern. The pattern can first be secured with shellac, further secured by carefully soldering or clamping extreme points and then permanently secured with screws. The advantage of such a mounted plate is limited chiefly to hand molding. For all-around service the better plan is to use separate plates for cope and drag.

The execution of the separate plate idea is identical with that of the single in principle. It is more easily accomplished in that it permits a pin and hole flask to be used in making the mold, does away with the long double pin and offers better opportunities for securing the pattern. In mounting the larger patterns a very efficient plan is to dust parting on the mold, blowing it clean from the patterns, moisten the plate, set it on and lift it off thus getting an outline of the pattern positions. At judicious points, drill holes entirely through the plate, set the plate back and continue these holes into the pattern; lap the pattern holes for a machine screw, enlarge the holes in the plate to admit the screw freely, set the plate back on and screw the pattern tight. In pursuing this plan it is obvious that the mold should be rammed exceedingly hard and the drilling done by hand, approximately perpendicular to the planed surface of the plate. Along the line of this idea many variations can be reasoned out.

Obtaining mounted pattern from the sand impressions of the individual pattern, presuppose a minimum shrinking pattern compound to be melted and cast on the plate. Most of these compounds are expensive and in every case where size will permit adhere closely to lightening cores to reduce quantity. In accomplishing this we get the pattern outline on the plate as previously noted and paste and dry a reduced core reproduction of the pattern within these lines. The formula we use for this pattern compound differs from those we have recently seen given in *The Foundry*, though we have no reason to believe it any better and would recommend any of those given in the June issue for a good one.

In making the mold we use French sand for a facing, ram the mold solid, cut the gates and dry it. On the single plate calculate approximate pattern position as indicated in the accompanying illustration.

Draw an approximate center line *XY* and a perpendicular bisector, *DK*. Parallel to *DK*, draw line *ah, bi, cj, el, fm,* and *gn;* mark off equi-distant from line *XY* points *a, b, c, D, e, f, g, h, i, j, K, l, m,* and *n* and set the pattern over these points. Drill a 3/8-inch hole




METHOD OF CALCULATING THE APPROXIMATE PATTERN POSITION

through the plate at these points and drill a ½-inch hole through the plate at *V* for the gate. In making the cope set the sprue over *V*, heat the plate slightly and assemble the mold with the plate in pinhole position, and clamp securely. In using a tin constituent compound it is often of advantage to *tin* the plate in the locality of the pattern occupation. Pour the compound into the sprue over point *V* allowing plenty of time in feeding the gate.

*Sand Impression Plan*

The separate plate sand impression plan can be reduced to a consideration of pattern retaining design. This opens up a wide field, as many methods can be pursued. We shall briefly note but three:

Tin the plate in space of pattern occupation.

Bore ½-inch holes through the plate at judicious points of pattern position, counter sinking on the opposite side of the plate.

Tap holes at judicious points of pattern position on the plate and screw T or cross-topped studs on the plate tapped holes.

Do anything to retain the cast pattern undisturbed in its mold position on the plate. In pouring the pattern mold, the flask is set with the mold side up, covered by the plate, into the gate hole of which the metal should be poured through a sand riser or head. When a countersunk hole is used in pattern retention, the metal can be left to rise in these holes and shrinkage fed in as it occurs, or they can be covered with cores firmly weighted down. Some of the neatest and most correct patterns we have were mounted in this way.

Patterns of depressed parting lines necessitate a depression in the drag plate and an elevation in the cope. This depression can be cast in the plate and a metal form identical in size and contour fitted in. This form can be worked out of a piece of metal or cast of white metal using the depression in the plate as an iron mold. It can easily be fitted to a level cope plate by drilling and tapping when the cope plate is fitted and clamped in pin-hole position to the drag plate, or can be cast on the cope plate by drilling two countersunk holes and pouring with the plates in this position.

*Stripping Plate Additions*

The stripping plate addition can be taken care of with little difficulty. The cope and drag stripping plate can be cast with openings to conform to the contour of the pattern halves. Clamped together with these pattern lines coinciding, they can be drilled on the jig and filed out a shade larger than the pattern halves. Slight draft should be given for the cast pattern. In making the drag of the mold the stripping plate should be in pin-hole position on the pattern plate. In casting or attaching to the pattern plate, the stripping plate sets between the pattern plate and the mold. In applying the stripping plate, care should be exercised to observe and file away any parts of the pattern line on the plate that may overlap those in the mold. In mounting the individual pattern, pieces of wood or metal can be used to take up the thickness of the stripping plate, being identical in contour with the pattern and attached to it in making the drag of the mold.

A few general suggestions follow:

Keep a set of true flasks and pins in good order and use for no other purpose.

Always heat plates before casting.

Plates with lightening cores should always be set on and lifted off to verify proper core position.

In taking relative positions, plates and flasks should be plainly marked to avoid confusion in assembling.

Two-pinned flasks with pins and holes in the center line of the flask seem to give best satisfaction.

# The Influence of Occluded Gases in Cast Metal

*A Discussion of the Action of Metal in Cooling Molds, and the Effect of Gases Upon the Phenomenon of Shrinkage*

By J E Fletcher

THE precise constituency of molten cast iron and steel is, to a large extent, unknown. That it must contain in solution iron, carbon, silicon, manganese, phosphorus and sulphur, is known, but exactly how these metals and metalloids occur when in the liquid state cannot yet with absolute certainty be defined.

Our experimental evidence is gained from chemical analysis and microscopic examination from the solid material alone, but research has revealed the fact that the above named elements are largely present combined with one another, the constituents carbon and iron alone existing in the free state.

It may further be remarked that carbon and iron are usually found in both the free and combined state in all carbon-iron alloys, excepting perhaps that free carbon is not found in low carbon steels and iron in the pure state does not occur in the cast iron group.

These alloys solidify first and are followed by others in ordered succession. In cast iron, for example, the microscope reveals a constituent which is a mechanical mixture of iron carbide and iron, known as the eutectic, containing 4.3 per cent of carbon, and also another somewhat similar constituent containing 0.9 per cent of carbon, known as the eutectoid. Now, if quenching fixes the constituents present at the time of so doing, then the microscopic representation of the quenched alloy must resemble closely that of the virgin molten metal. The author has made many such experiments in the way of quenching various carbon iron and other alloys from the molten state and believes that there are definite structures even in the liquid metal itself.

It is unconventional perhaps to consider eutectics as existing above the temperatures of their melting points, but it is certain that the 4.3 per cent carbon eutectic can be superheated to 1,500 degrees Cent., which is the melting point of iron, and on being quenched will still reveal under the microscope a characteristic stratified honeycomb structure. The silico-ferrite crystallites under such circumstances are small, but of the characteristic fir tree or dendritic structure. It may be that there are liquid iron crystals as Quincke and Schenck have surmised, in a liquid matrix of eutectic composition and that these crystal forms and the eutectic structure are preserved by sufficiently brisk quenching from the molten condition. Gases are imprisoned or dissolved in all molten metals, and in cast iron and other eutectic-containing metals or alloys these gases are very probably the formative or directive element in the growth of the honeycomb-like formation of the primary eutectic. The flow line structure always having a direction towards the upper and hotters portions of the freezing mass of a eutectic ingot gives the impression of fine gas streams set in motion by convectional forces just as the streams of steam bubbles are given convectional flow in a boiler. It may be that the primary gas streams in flowing through the semi-liquid carbide of iron plate-like crystals make the paths through which the more or less carburized ferrite enters and freezes, such freezing action being immediately afterwards followed by that of the carbide.

Fig. 1 shows a pure eutectic iron quenched in iced brine after superheating to 1,500 degrees Cent., 370 degrees above its melting point. Fig. 2 illustrates a cast iron quenched from above the melting point, while Fig. 3 shows the same iron when slowly cooled down to the approximate temperature of the room.

The structure of a cast iron must have some relation to the primary structure it received in the blast furnace. The iron was reduced there from the ores, and descending became carburized by contact with the coke and carbon monoxide gas, the latter being the chief carbonizing agent. As it approached the hot zone of the boshes, it absorbed sufficient carbon to make a fusible alloy and in such state flowed down into the hearth having a composition approximately that of the eutectic and having by that time probably a distinctive structure. If this eutectic alloy has not ab-

An abstract of a paper presented at a meeting on Nov. 27, 1916, of the Birmingham branch of the British Foundrymen's Association.

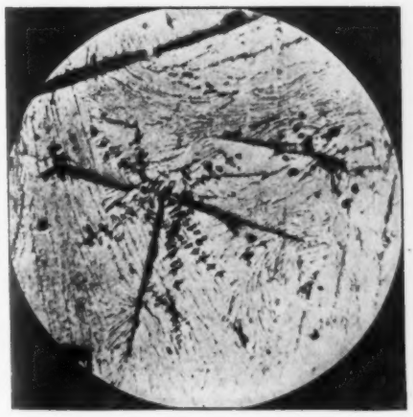


FIG. 1 — PHOTOMICROGRAPH OF A PURE EUTECTIC IRON QUENCHED IN ACID BRINE FROM 1,500 DEGREES CENT.

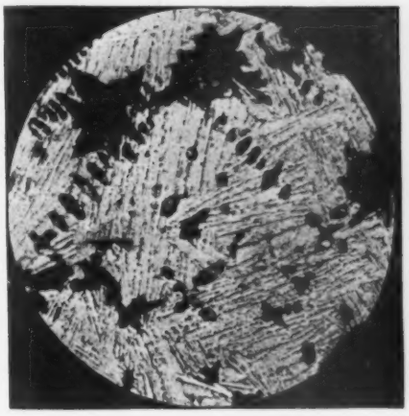


FIG. 2 — PHOTOMICROGRAPH OF A CAST IRON QUENCHED FROM ABOVE THE MELTING POINT

FIG. 3 — PHOTOMICROGRAPH OF THE SAME CAST IRON IN FIG. 2 WHEN SLOWLY COOLED TO ROOM TEMPERATURE

FIG. 4 — FRACTURE OF CAST IRON INGOT SHOWING THE DIRECTION OF THE PRIMARY CRYSTALS

sorbed enough carbon to become the true 4.3 per cent carbon eutectic or if it becomes bessemerized by the blast, then iron crystals are thrown into the eutectic and the structure has then the constituency of iron crystals plus eutectic.

These crystals become more or less carburized, but though they grow during the slow cooling in the casting bed, they preserve their entity, possibly permanently, since they may be found as part of the crystalline structure of a mild steel. Let us briefly consider the changes which take place during the reduction of the ore in the blast furnaces and further to the completion of the alloying period in the hearth. While the ores are being reduced, the oxides of silicon, manganese and phosphorus remain unaffected. During this period the iron oxides are attacked by the carbon monoxide gas, which is the principal reducing agent, as it is the chief carburizing medium. Now each particle of iron oxide must come into contact with the reducing gas or with the carbon of the coke. The latter contact cannot be so great a factor as is sometimes considered, since the coke descends in large measure unbroken into the hearth. It is well known that the reduction of the ore is accomplished by means of the gas CO; about 1.2 pounds of the gas $CO_2$ are set free for each pound of iron reduced. At the temperature of such reduction, say at 1,400 degrees Fahr., the volume of the gas is about three times its bulk at 60 degrees Fahr., hence it will be possible to prove that each pound of iron oxide, $Fe_2O_3$, in the ore when attacked by the gas CO liberates over 5,000 times its volume as $CO_2$ gas. It is not, therefore, difficult to imagine that as a result of such gaseous action the porous nature of the reduced iron is aptly called spongy. This may be called the first stage in the gas absorbing tendency of iron, for it is impossible to reasonably conclude that within the meshes of the spongy iron there can be freedom from gas imprisonment.

The presence of hydrogen in the gases imprisoned by this action is readily understood when we consider that the gases which attack the ores are a mixture of moisture evaporated from the blast, ores, flux and fuel; air; carbon dioxide gas from the decomposition of the limestone; and carbon monoxide gas, CO, produced by the incomplete combustion of the coke and liberated by the ore which is partly reduced by direct contact with the carbon of the coke.

The fracture of the metals conveys a great deal to the practiced eye, and an examination of the upper surface of cast iron as it runs into the pig bed and of its cooled exterior is often

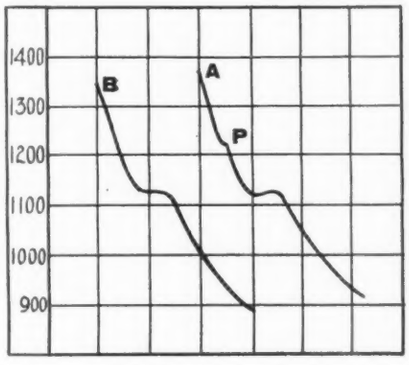



FIG. 5—COOLING CURVES OF LOW SILICON PIG IRON

an index as to the effect of carbon, phosphorus and silicon. But the miscroscope is an invaluable and indispensable aid to the structure, as is the recording pyrometer to the behavior of the metal from its freezing point to the cold state. The use of the microscope, however, is an acquired art, which requires long practice and it cannot be too strongly urged that the effects of temperature, slow and rapid cooling, the influence of mass on the structure of cast iron and steel of many varying analyses be studied closely before the microscope can yield really useful results. Similarly the cooling curves taken, from small samples may be misleading. Thus two small ingots of cast iron may be made from the same pig, one being carefully protected from oxidation during melting, the other free to surface oxidation. If such samples are melted and superheated to temperatures much in excess of their actual fusion point, the cooling or freezing point curves will be dissimilar, though there may be but little difference in the analyses of the two specimens. A low silicon pig iron was melted and the cooling curves taken were as shown in Fig. 5. The break in the curve *A* indicates the fact that the iron oxide formed during the superheating of the sample had partially oxidized the carbon of the carbide and had caused a separation of free iron crystals from the eutectic. This separation takes place at a higher temperature than that of the normal pig iron and is shown by the break in the curve at the point *P*.

In the study of the gas influence the principal use of the microscope is in tracing the difference in crystalline structure between the outer rapidly cooled and the inner slowly cooled zones of a casting. If the cooling curves are taken simultaneously at each of these zones, then in many cases the difference in the freezing behavior with its action on the phenomena of shrinkage and contraction may be observed. Thus in a high phosphorus iron there is considerable segregation of the phosphorus as phosphide eutectic towards the center of the casting mass and it is not unusual to find this reflected in the cooling curves taken from the exterior and the interior of the casting. The reason is, of course, that the higher phosphorus content of the interior lowers the freezing temperature at that point.

Just previous to freezing of cast iron or steel, the liquid metal may be conceived to consist of an agglomeration of liquid particles or crystals of iron more or less carbonized, silicide and phosphide of iron, carbides of iron and manganese, and of the sulphides of iron and manganese. Crystallites or fir tree shaped dendrites of partly carburized iron in the midst of a mother liquor which is made up of

FIG. 6—FRACTURE OF CAST IRON INGOT SHOWING THE DIRECTION OF THE GAS STREAMS

carbide, phosphide, silicide and sulphide of iron, and of manganese carbide and sulphide, first separate out and freeze at the mold surface and at right angles to it. Almost immediately afterwards the silicide of iron freezes around the iron crystallites. These crystallites as they freeze eject their occluded gases which they originally contained, into the mother liquor or eutectic. As the iron or silico-iron crystals elongate and grow laterally, the gases are driven inwards, producing a flow of the mother liquor in that direction, toward the hot and fluid mass center. The volume of any such partially frozen portion of the metal is as follows: Primary crystals, $A$ + mother liquor, $B$ + ejected gases, $C$. As $A$ increases, $B$ decreases, while $C$ simultaneously decreases. In cast iron the mother liquor $B$ contains the segregate, slag, oxide and sulphide particles, together with the graphite flakes which escape with the gases into the hot fluid portions which, when frozen, contain the highest percentages of these impurities. The gases thus liberated travel to the hot zones in the castings which are the last to freeze. If there is no way for these gases to escape to the surface of the ingot or casting or by way of a riser, then gas cavities or pipes must occur. The function of feeding is, therefore, evident. As freezing progresses from the outside of a casting inwards, driving the gases to that point, unless a path is kept clear, and hot fluid metal can take the places of the gas bubbles or streams, gas cavities or spongy spots must remain.

*Path of Ejected Gases*

In a square ingot the crystals forming at the surfaces of the chill mold start freezing at right angles to the cooling surfaces. The crystals forming at the corners must meet one another in their growth and a plane of weakness is produced at each corner of the ingot. At the bottom of the mold crystals grow which in freezing meet the crystals growing from the sides and there is formed a pyramid whose surfaces are planes of weakness. Along these planes the ejected gases travel together with the segregates and slag particles, eventually reaching the central axis of the ingot through which they ascend to the ingot top. The action of the gases which escape into the mother liquor when the primary crystallites begin to form and grow, is much more important than has been generally considered. The natural tendency of the primary crystallites to grow at right angles to the mold side or chill surface is disturbed in many cases by the influence of the gas streams whose direction is always towards the point of easiest escape. This direction of flow is, of course, towards the hot fluid mass centers and naturally upwards. In a series of small cast iron ingots of taper

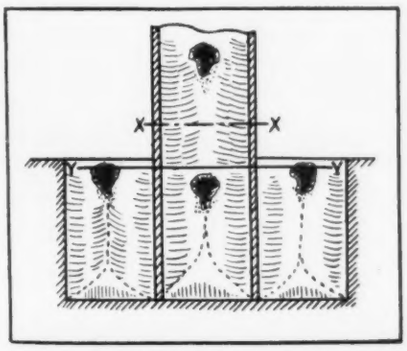



FIG. 7—ILLUSTRATING PIPING IN A GRAY CAST IRON BLOCK

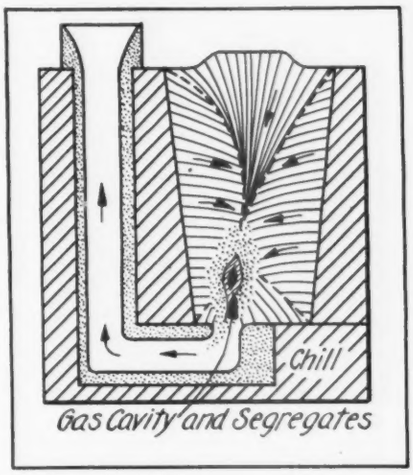



FIG. 8—SHOWING THE EXIT OF GAS TOWARDS THE VENT, AND THE DIRECTION OF THE GAS PATHS DOWNWARD

form the direction of the gas streams and of the primary crystals is clearly seen in the fractured surface, as illustrated in Figs. 4 and 6. This surface when polished and etched was examined under the microscope and it was concluded that the curved lines of the fractured surface corresponded to the directions of the long axes of the primary crystallites and to those of the plate-like crystals of the eutectic.

When there is no exit at the top of a casting whereby the liberated gases can escape, these will flow towards the vent wherever this is placed and in one case a downward flow was observed. A small ingot was run from the bottom through a trumpet runner as commonly used in the casting of steel ingots in closed top molds. The mold was first filled with molten slag, which was immediately afterwards displaced by molten-white cast iron. The result of the experiment, shown in Fig. 8, was that the gas paths ran downwards. In cast

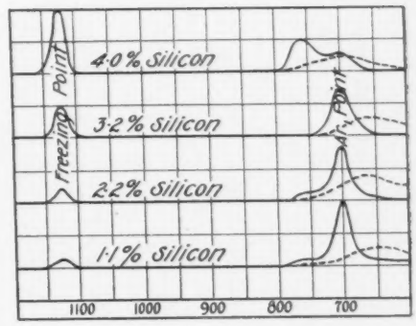



FIG. 9 — DILATION OF CAST IRONS; THE INFLUENCE OF 2 PER CENT MANGANESE IS SHOWN BY THE DOTTED LINES

iron ingots the phosphide of iron and the sulphides together with the graphite liberated, travel along the planes of weakness, being assisted by the propelling motion of the escaping gases.

*Shrinkage is Vital Problem to Foundrymen*

An important question arises in connection with the phenomenon of shrinkage. Is the phenomenon of shrinkage connected with the volume of occluded gases, or rather with that of gases escaping during the freezing of iron and steel? There are many evidences in favor of such a conclusion. A case in point was that of a mild steel block, which was cast from a ladle of well melted steel held in the ladle accidentally until close on the point of setting or congealing. The nozzle gave out and did not allow scarcely any steel to rise in the casting head or riser. When cold, the block was found to have contracted less than 1/16-inch per foot. The metal, when planed, revealed no pipe or cavity and was free from blow-holes. The weight of the casting indicated soundness. This case points to the fact that the gases escaped freely during the slow rising of the steel in the mold and that the occluded gases finally remaining in the metal mass were in a fine state of entanglement between the crystals, uniformly throughout the mass. A similar casting made in the same heat from a more fluid steel piped deeply in the rising head and contracted normally at the rate of 0.2-inch per foot.

In another case a gray cast iron cylindrical block was cast, in the center or axis of which was fixed an iron tube twice the depth of the block, as shown in Fig. 7. The molten iron was run into the mold surrounding the central tube or core. The iron tube was next filled with metal and the whole allowed to cool slowly. When parted near the upper surface of the block at *YY* the expected ring-shaped pipe was found in

the outer ring, but the inner tube was found to be perfectly filled with metal which had not contracted. The inner ingot was again parted just above the block at *XX* and here again no contraction had occurred, though at the top of the inner tube or ingot there was a slight shrinkage. Two gas cavities were found in the inner ingot, one at the top and another almost opposite the top of the cylindrical block. The explanation would seem to be that the metal in the lower half of the inner ingot, being surrounded by a heated mass of the same temperature froze so slowly that it ejected its gases axially and upwards, the bubbles being perfectly replaced by liquid metal. Hence the lower half of the central ingot did not contract. The escaping gas met the bridge of congealed metal just above the block and was imprisoned, forming the lower cavity. The gases in the upper half of the tube escaped to the top, forming the usual pipe.

Whenever castings are made in chilled molds, there must be shrinkage or contraction. Under such circumstances, rapid freezing has a tendency to form small primary crystals which become quickly interlocked imprisoning small gas bubbles. The cooling of the mass causes a shrinkage of the gas bubbles and it has been concluded that each gas globule occupies much less volume at 60 degrees Fahr. than at 2,000 degrees Fahr.

**Percentage of Composition and Shrinkage Per Unit of Volume of Iron**

| Combined carbon. | Graphite. | Si. | Mn. | P. | Volumetric contraction. | Class of iron. |
|---|---|---|---|---|---|---|
| 0.45 | 3.33 | 2.8 | 1.2 | 0.8 | 1/135 | Coarse gray |
| 0.40 | 3.01 | 1.5 | 1.3 | 0.4 | 1/100 | Light gray |
| 0.95 | 2.35 | 1.0 | 0.4 | 0.7 | 1/77 | Mottled |
| 1.20 | 2.15 | 0.9 | 0.2 | 0.4 | 1/75 | Mottled |
| 1.50 | 2.10 | 1.0 | 3.2 | 0.5 | 1/58 | White iron |
| 5.00 | 0.20 | 0.7 | 11.2 | 0.1 | 1/50 | Spiegel |

Great strides have been made in the United States in foundry science in showing how volumetric change during the freezing and later cooling of iron varies with differing analyses. The clearest illustration of the relationship between the chemical analysis of cast iron and the behavior during cooling from the freezing point with the accompanying shrinkage has been given by Professor Turner. He has related the freezing and the shrinkage curves and in typical cases has shown that each grade and type of pig iron expands on freezing and shrinks in its own characteristic way. It was believed by Professor Turner with Messrs. Goe and Hague that when either silicon, manganese or phosphorus was added to a pure carbon iron, either singly or together, there was an expansion at the moment of freezing. In white cast iron containing about 3.5 per cent carbon and 96.5 per cent iron there is no such expansion, but a rather rapid shrinkage or contraction. The addition of silicon alone up to 3 per cent increases the expansion regularly and similarly the addition of manganese alone up to 2.5 per cent increases the primary expansion, the amount of such expansion per unit of the metalloid added being roughly the same in silicon as in manganese. Now when the two elements, silicon and manganese, are added to the 3.5 per cent carbon iron it is found that the primary expansion is increased and if a third element, phosphorus, is added, there is a further increase. In all cases, there is a halt in the rate of shrinkage and often a considerable second expansion when the recalescence point known as the pearlite point, is reached during the cooling down from the freezing or solidification point.

Just after freezing commences, when the primary fir tree type of crystals begin to form next to the mold surface, a certain amount of the iron carbide decomposes and is thrown out into the mother liquor as graphite flakes. This is one possible reason for the primary expansion. But when these silico-ferrite crystallites form they liberate a certain quantity of heat and at the same time eject a considerable volume of the gases which they held in solution when liquid. These gases, when thrown into the thin fluid mother liquor, would contribute to the expansion of the whole metal mass at that moment. When phosphorus is present, the mother liquor is made increasingly fluid and is capable of holding more gases in solution, permitting their ready flow. The gases then, as may be argued from the appearance of the micro-structure as quenched in this range of temperature, must be widely distributed as minute bubbles. At the point of recalescence there is another expansion generally, connected, as Professor Turner suggests, with the liberation of more free carbon or temper carbon, and probably with a further increase in the volume of the gases as a result of the heat evolution which then takes place. Baker in his experiments on the quantity of gases drawn off from iron and steel heated in a vacuum decided that the greatest quantity is ejected at the recalescence point, thus confirming the work of the earlier investigators, Troost and Hautefeuille, and Muller. More recently Charpy concluded that the expansion or dilation of carbon-iron-silicon alloys was increased at the freezing point as the silicon content rose, while the expansion at the recalescence point is diminished, as the plotted curves in Fig. 9 show. This conclusion confirms experiments made by the author on cast irons with varying silicon content some years ago, when it was further found that manganese and silicon together intensified such action. Generally speaking, white irons shrink most, the more highly siliceous irons shrink least. It is believed that silicon and aluminum tend to retain the gases in a fine state of division within the cooling mass, the decomposition of the carbide of iron is facilitated, graphite liberated with considerable evolution of heat, while the primary crystals are being formed or frozen. Hence gray siliceous irons solidify slowly and shrink least because of the occluded gases present in the mother liquor, which is the ideal condition for the free growth of the graphite flakes. It would seem that whenever the iron carbide in either the primary crystals or in the eutectic is retained, as is the case when manganese or chromium is present, the speed of freezing is increased and the gases liberated are driven rapidly into the more fluid portion of the metal mass where there is a tendency to form shrinkage cavities. In low silicon irons free from phosphorus, high manganese generally produces such results especially if the casting temperature is low. In the case of high manganese irons with high carbon content used in rapidly cooled castings the difference in the shrinkage rates between the outer freezing zones high in combined carbon and the inner zones of gray iron, not rarely results in pulls or draws in the outer skin. This is true especially in the neighborhood of internal corners where three planes meet. The presence of phosphorus is an aid to gas escape into the hot interior of a cooling casting. The increased fluidity given by reason of the fluid phosphide eutectic makes it easy to feed castings made from metal containing above 0.4 per cent phosphorus. The feeding process is really the means of supplying liquid metal to take the place of the gases which are being liberated as the primary crystals are growing at the expense of the gradually diminishing mother liquor. When by reason of low carbon content the constituency of a

cast iron is steely in its nature then there is great danger of internal sponginess.

The question of hot casting is, of course, allied with the problem of shrinkage and of gas exit. Generally it may be stated that when the metal is hot cast, when its molten temperature is higher than that necessary to simply melt it, the gases which are liberated during freezing are driven into the hot interior and as they escape to the risers, their place is taken by liquid metal. There is a better distribution of the gases which remain in the cold metal and less risk of blow-holes and gas cavities common with cold cast metals.

*Hot Casting Permits Escape of Gas*

With hot cast metal these gases are more uniformly distributed throughout the casting, a greater part escaping through the riserts or feeding heads. The importance of hot casting will be at once seen when dealing with pure irons of hematite and cold blast character, low in total carbon, phosphorus and silicon. Such iron cools and shrinks rapidly because its primary crystals freeze at a high temperature, and the mother liquor being more purely eutectic, freezes rapidly. Being difficult to feed, owing to the passage through the "pasty" stage, the gases pent up in the mass centers of the casting become frozen in and remain as shrink holes or gas cavities. Cast irons which are high in silicon and phosphorus do not suffer from the slow freezing of the eutectic. The mother liquor, which is a kind of compound eutectic, has a longer freezing range than the simple 4.3 per cent carbon eutectic. Moreover, during the freezing of the primary crystals the carbide of iron decomposes, graphite being liberated. The heat evolved keeps the mother liquor in a fluid condition and there is no "pasty" stage. Anyone who has observed the puddling of such irons will understand the difference between the behavior of a white refined iron of the old refinery plate type and that of a Lincolnshire gray pig iron. The latter is liquid for a much longer period than the former, and is most difficult to puddle, because the primary crystals remain for so long in an almost fluid state. Manganese retains the carbide in the eutectic and is an aid to rapid freezing. It also stiffens the primary crystals. It has a powerful effect in conjunction with silicon in suppressing the heat evolution at the pearlite point as the cooling curves show. It has been generally noticed that such suppression of the pearlite point, if accompanied by a lowering of the freezing point, indicates a tendency to rapid freezing of the primary crystals which are found to retain the austenitic condition even when slowly cooled.

With reference to the character of the gases occluded in iron and steel, a great deal of research work has been done, notably by Dr. Baker. Gases exhausted in a vacuum from cast iron and steel at temperatures in excess of 900 degrees Cent. have given the following analyses:

INCLUDED GASES IN IRON AND STEEL

| | Per cent, by volume. |
|---|---|
| Carbon monoxide | 45 to 50 |
| Hydrogen | 45 to 55 |
| Carbon dioxide | 0 to 5 |
| Methane | 0 to 3 |
| Nitrogen | 0 to 4 |

The importance of taking into consideration the influence of gases in the foundry problem can scarcely be underestimated. Unless efficient means are taken to secure the easy escape of gases liberated during the solidification of cast iron and steel, the occluded gases which remain entrapped expand again during the recalescence and may do further damage. The major portion of foundry troubles are associated to a certain degree with the question of included gases. The gases which are set free at the mold surfaces due to the driving off of moisture in the sand washes or molding composition or of volatile matter, belong to a different category and should, of course, be dealt with separately. The practical value of investigations is seen when the compositions of pig irons are compared with their shrinkage per unit volume during the cooling down from the freezing point to the temperature of the atmosphere. The figures shown in the accompanying table may be found useful in supplementing the observations which have been described.

## Barlow Foundry Reorganized

The historic Barlow Foundry Co., Newark, N. J., the continuation of the business established by Seth Boyden, the originator of malleable iron, has been reorganized as Barlow Foundry, Inc., and will be continued. About three years ago the company built a splendid new plant at Newark, alluded to as a model by the state of New Jersey labor commissioner, but the cost of construction was not properly financed and this, combined with losses on account of poor business conditions in 1914 and the early part of 1915, resulted in the appointment of a receiver. The reorganized concern has an authorized capital of $250,000, of which $122,000 has been issued to creditors and stockholders in the old company. Also approximately $25,000 new capital has gone into the company. The officers are as follows: President, Walter Kidde, of Walter Kidde & Co., 90 West street, New York; vice president, Jos. Perrine; secretary and treasurer, Arthur E. Barlow. In addition to the officers, William Fellowes Morgan, president of the Merchants' Association of New York, and Samuel Dixon, of Wm. Dixon, Inc., New York, are directors. John Lawrence Carter, graduate of Stevens Institute of Technology, and formerly head of the efficiency department of the Hyatt Roller Bearing Co., Harrison, N. J., is the foundry manager.

## Safety Awards Announced

The annual awards of medals to firms or corporations which have performed signal service in the promotion of industrial welfare and safety has been announced by the American Museum of Safety, 14 West Twenty-fourth street, New York. The Commonwealth Steel Co., of St. Louis, has received the Travelers Insurance Co. medal for protecting the lives of its workmen; the Julius King Optical Co., of New York, the Louis Livingston Seaman medal for the promotion of hygiene and the mitigation of occupational diseases as a result of its investigation of the effect of colored lenses worn by workmen; the Pullman Co., the Scientific American medal for developing the Dean endframe for passenger cars to prevent telescoping, representing, in the opinion of the awarding board, the most efficient safety device invented within a period of years; the Anthony N. Brady medal to the Connecticut Electric railway, of New Haven, as the American electric railroad which has done the most to safeguard the lives of its men. The E. H. Harriman medal for the railroad which has made the best year's record in guarding the safety of passengers and employes is to be awarded later.

The offices of the Institute of Metals have been transferred to 36 Victoria street, London, S. W., because the Caxton House, former home of the institute, has been commandeered by the British war office. The new quarters include a reading room, library and a large assembly hall. The next meeting of the institute, known as the annual May lecture, will be given at the Institution of Civil Engineers, Great George street, Westminster, S. W., on Thursday, May 3. Prof. W. E. Dalby will speak on "Researches Made Possible by the Autographich Load-Extension Optical Indicator."

# The Inspection of Bronze and Brass Castings

*How Defects in Non-Ferrous Metal Castings Not Revealed by Surface Inspection May Be Discovered—Repairing Leaks and Preventing Cracks*

By Ernst Jonson

BRASS and bronze castings are subject to various defects which are difficult to discover by surface inspection, or even by hydrostatic testing, when such a test is practicable. The defect which most commonly occurs results from the inclusion of oxide in the metal of the casting. This occurs in two ways: Either the molten metal contains an admixture of oxides, owing to insufficient protection of the molten metal from the air, or the dross from the surface of the crucible or furnace charge gets into the mold and is caught at some point where the flow is slight, and is thus prevented from coming to the surface in the risers.

In the former case the entire casting is bad, and the best way to discover this defect is to make tensile tests on specimens cut from a coupon cast from the same melt. The admixture of oxide is indicated most distinctly by the greatly reduced elongation, but also by low ultimate strength. The tensile test should therefore, be specified for all important brass and bronze castings, no matter whether a certain strength and elongation are of mechanical value or not. The metal in every important brass or bronze casting should have the strength and elongation typical of the mixture of which it is made as an evidence that the metal in the casting is clean. If a tensile test is impracticable, oxidation in the metal may be discovered by making a bending test on a machined specimen. The presence of oxide will then be indicated by a number of small cracks which open on the outside of the bend, and if the oxidation is extreme, also by the abnormal color of the surface of the fracture.

The writer's experience indicates that oxidation of metal in the crucible is a very common defect, especially of the mixtures of high percentage of copper, that is, of the bronzes. It is the writer's belief that in foundries where tensile or hydrostatic tests are not made, the metal is generally allowed to become considerably, and in many cases seriously oxidized in the crucible, because this defect in the metal does not show on the surface of the casting. To specify bronze castings merely by the mixture is therefore useless. Unless the metal is tested after it has been poured, one is not justified in assuming that it consists of a clean, uniform mixture of the ingredients put into the crucible, or even that the proportions of the mixtures are the same as originally made, for the proportion of one or two of the ingredients may have been decreased by oxidation. A bronze casting may be made of the correct mixture and may show no surface indications of defects, and still it may be nothing but a honeycomb of metal, the cells of which are filled with oxides.

*Correct Molding Necessary*

It is more difficult to discover the presence of included dross. If a hydrostatic test cannot be made, it is practically impossible to find such defects unless they happen to come to the surface of the casting, and even a hydrostatic test does not always discover such defects, because there may be considerable thickness of good metal along one or both of the surfaces of the casting. The best insurance against this kind of defect is correct molding, which strange to say, is very unusual. Poor molding, however, cannot be charged entirely to the foundryman. The designer is often equally at fault. The molding of a casting should be planned while the casting is being designed, and before its final shape is determined. Every brass or bronze casting should be designed with reference to a given position in the mold. The position being determined, the various parts of the casting should be so arranged that they are connected by a rising channel of increasing cross-section and with a minimum of offsets with one of the risers, which, of course, should be of much greater diameter than the thickest part of the casting. The chief reason for this rule is evident. The thinner the metal the sooner it solidifies; hence if a portion of the casting is separated from the riser by another part of the casting which is of less thickness, the metal in the heavier part of the casting would be fed by the riser only to the point at which the thinner connecting portion of the casting solidifies. After that the shrinkage will result in the formation of cavities in the heavy part of the casting. Chills may be used to some extent as a substitute for this arrangement, but only when a channel of increasing dimensions is impracticable.

When a casting is correctly designed with reference to molding, it is evident that there is much less likelihood of dross being caught in the mold, but that instead it will flow up into the risers. The foregoing presupposes, of course, that the pouring gate enters the mold at its lowest point.

Whenever practicable, castings should be poured from the bottom. There are certain castings which cannot be poured from the bottom, but it is a question whether castings poured from the top are ever quite free from dross. Hence, very important castings should be so designed that they can be poured from the bottom. Doing this will sometimes involve considerable expense, as the castings may have to be made much thicker than they need be, and perhaps, also, much machine work may be required to bring them down to the desired dimensions.

In determining the position of the casting in the mold extensive flat upper surfaces should be avoided, as dross may accumulate by being caught under the flat surfaces of the mold or core. When a flange forms the upper surface of the casting, it should be expected to contain some dross and an adequate amount of finish should be allowed so that this dross will be entirely removed in machining.

Inadequate risers constitute another source of trouble. A casting may be made in full accordance with the drawings and specifications, and yet contain deposits of dross which may cause it to fail under ordinary working conditions. These defects may be such that they would not be discovered by the most careful inspection, and even by a hydrostatic test. It is therefore unwise to leave the decision as to the number and size of risers to the foundryman who may be prejudiced by consideration of economy in favor of fewer and smaller risers than is consistent with the highest quality of casting. It would seem, therefore, that in specifying brass or bronze castings the total cross-section of the risers should be given in per cent of the greatest horizontal cross-section of the casting.

Brass and bronze castings are expensive to make, and it is therefore undesirable to reject such castings on account of defects which can be rem-

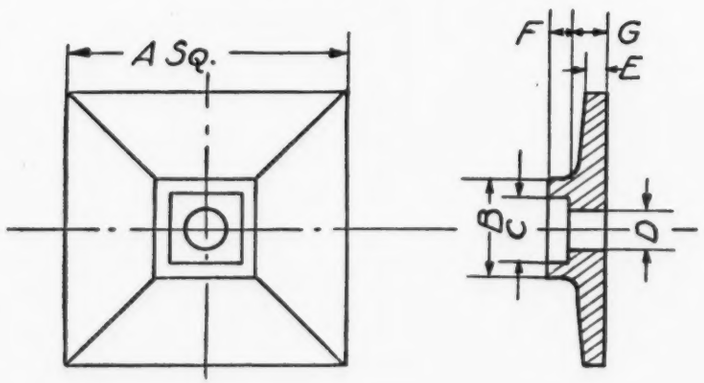
From a paper presented at the Cleveland meeting of the American Institute of Metals, Sept. 11 to 15, 1916. The author, Ernst Jonson, is engineer inspector, New York board of water supply.

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

## STANDARD FOUNDATION WASHERS

*By George W. Childs*

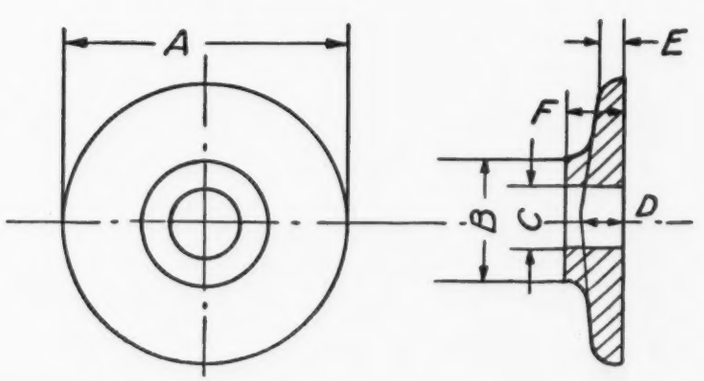



| Diam. of Bolt | A | B | C | D | E | F | G | Est. Wt. Lbs. C. Steel |
|---|---|---|---|---|---|---|---|---|
| ½″ | 5″ | 1½″ | 1 ″ | 9/16″ | 3/8″ | 3/8″ | 5/8″ | 3.68 |
| 5/8 | 5 | 1 11/16 | 1 3/16 | 11/16 | 3/8 | 3/8 | 5/8 | 3.75 |
| 3/4 | 6 | 1 7/8 | 1 3/8 | 11/16 | 1/2 | 1/2 | 3/4 | 6.6 |
| 7/8 | 6 | 2 1/16 | 1 9/16 | 11/16 | 1/2 | 1/2 | 3/4 | 6.6 |
| 1 | 7 | 2½ | 1¾ | 1⅛ | 5/8 | 5/8 | 7/8 | 11. |
| 1⅛ | 7 | 2 11/16 | 1 13/16 | 1¼ | 5/8 | 5/8 | 7/8 | 11. |
| 1¼ | 8 | 2 7/8 | 2⅛ | 1⅜ | 5/8 | 5/8 | 1 | 15.2 |
| 1½ | 8 | 3¼ | 2½ | 1⅝ | 5/8 | 5/8 | 1 | 15.1 |
| 1¾ | 10 | 3 7/8 | 2 7/8 | 1 7/8 | 3/4 | 3/4 | 1½ | 33. |
| 2 | 10 | 4¼ | 3¼ | 2⅛ | 3/4 | 3/4 | 1½ | 33. |
| 2¼ | 12 | 4 7/8 | 3 5/8 | 2 3/8 | 7/8 | 1 | 2 | 60.6 |
| 2½ | 12 | 5¼ | 4 | 2 5/8 | 7/8 | 1 | 2 | 61. |
| 2¾ | 15 | 5 7/8 | 4 3/8 | 2 7/8 | 1 | 1¼ | 2¼ | 107.8 |
| 3 | 15 | 6¼ | 4¾ | 3⅛ | 1 | 1¼ | 2¼ | 107.6 |
| 3¼ | 18 | 6 5/8 | 5⅛ | 3 3/8 | 1⅛ | 1½ | 2¾ | 182.9 |
| 3½ | 18 | 7 | 5½ | 3 5/8 | 1⅛ | 1½ | 2 3/4 | 182.7 |

The Foundry, Data Sheet No. 231, April, 1917

## STANDARD WOOD WASHERS

*By George W. Childs*




| Diam. of Bolt | A | B | C | D | E | F | Est. Wt. Lbs. C. Steel |
|---|---|---|---|---|---|---|---|
| ¼″ | 1¼″ | 5/8″ | 5/16″ | 3/16″ | 1/8″ | ¼″ | .06 |
| 3/8 | 1 7/8 | 7/8 | 7/16 | 5/16 | 3/16 | 3/8 | .18 |
| ½ | 2½ | 1¼ | 5/8 | 3/8 | ¼ | ½ | .42 |
| 5/8 | 3⅛ | 1½ | ¾ | ½ | 3/8 | 5/8 | .83 |
| ¾ | 3¾ | 1¾ | 7/8 | 5/8 | 3/8 | ¾ | 1.46 |
| 7/8 | 4 3/8 | 2 | 1 | ¾ | 3/8 | 7/8 | 2.14 |
| 1 | 5 | 2¼ | 1⅛ | 7/8 | 7/16 | 1 | 3.32 |
| 1⅛ | 5 5/8 | 2½ | 1¼ | 1 | ½ | 1⅛ | 4.72 |
| 1¼ | 6¼ | 2¾ | 1 3/8 | 1 | ½ | 1¼ | 6.06 |
| 1 3/8 | 6 7/8 | 3 | 1½ | 1⅛ | ½ | 1 3/8 | 7.67 |
| 1½ | 7½ | 3¼ | 1 5/8 | 1¼ | 9/16 | 1½ | 10.21 |
| 1 5/8 | 8⅛ | 3½ | 1¾ | 1¼ | 5/8 | 1 5/8 | 12.68 |
| 1¾ | 8¾ | 3¾ | 1 7/8 | 1 3/8 | ¾ | 1¾ | 17.35 |
| 2 | 10 | 4¼ | 2⅛ | 1½ | 7/8 | 2 | 24.9 |

The Foundry, Data Sheet No. 232, April, 1917

edied. Minor leaks in hydraulic casting may be stopped by peening, but the fact that the casting leaked at a certain point generally indicates that the metal was defective at this point. It is commonly believed that certain brass and bronze mixtures are normally porous and permit water to pass through them under high pressure. This belief, however, is erroneous, at least up to a pressure of 1,000 pounds per square inch. If water comes through the walls of a casting even in very minute quantities under pressures which do not exceed 1,000 pounds, the metal is not clean, or the casting is porous from some other accidental condition. Peening is therefore a questionable method of treating defective spots in brass or bronze castings. If the defect is small and other circumstances permit, a hole may be drilled and a plug of the same metal as the casting may be screwed in. If plugging is not practicable or permissible, defective spots should be cut out by chipping or drilling so that all the defective metal is removed. It is difficult to determine just how much cutting should be done, because any cutting tool that may be used will cause the metal to flow sufficiently to cover up minor defects and make it appear solid. Etching with a mixture of ferric chloride and hydrochloric acid would probably reveal poor metal thus hidden by the rubbing of the tool. The cavity may then be filled by melting metal into it from a rod by means of a gas flame, or by pouring metal into it from a crucible. In either case this must, of course, be done in such a way that the entire surface of the cavity is melted and thus consolidated with the metal that has been added. It is known that when brass or bronze is stressed above the initial elastic limit and the full stress is maintained for a considerable length of time, it will fail by cracking, as soon as oxidation takes place on the surface. When a defective spot in a casting is welded, the cooling of the metal in the weld will be accompanied by contraction which will put a tensile stress in the metal of the weld as well as in the old metal which surrounds it. If the metal of the weld is the same as that of the casting its elastic limit may be appreciably higher than that of the rest of the casting, because the metal in the weld solidifies much more rapidly than that in the rest of the casting. The permanent deformation resulting from the shrinkage of the weld will therefore take place in the surrounding metal, and this metal will remain in a state of tension greater than its initial elastic limit. Later, cracks will appear. If the casting is of small lateral dimensions, and the ends are not constrained, and the break extends all the way across it, the stress set up in the old metal by the shrinkage of the weld is compressive, and therefore there is no danger of cracking. In all other cases shrinkage stresses must be prevented by keeping the casting heated to a very high temperature while the weld is being made and until it has solidified. The elastic limit of the surrounding metal will thus be temporarily lowered and the flow will take place under a stress much lower than the initial elastic limit of the cold metal, so that there will be no danger of cracking after the metal has cooled. Another way to prevent cracking is to anneal the casting immediately after the weld has been made. There is no reason to believe that the metal surrounding the weld is injured by the shrinkage stress until corrosion occurs on its surface. Therefore, if the elastic limit of the metal surrounding the weld is lowered by heating the entire casting to a sufficiently high temperature, additional flow will occur, and the cooling stress thus gradually reduced to a very small minimum according to the length of time the annealing is continued. The annealing temperature should be maintained for several hours so as to give the metal time to flow. Repairs of this kind should be made before any machining has been done, because the dimensions of the casting may be appreciably affected by the shrinkage in the weld as well as by the annealing. Castings which are subject to hydrostatic test should be given a preliminary test before any machining is done. A pressure of 100 pounds or less will generally be sufficient to reveal defects.

In machining brass and bronze castings trouble frequently arises from the fact that the patternmaker did not make proper allowance for minimum shrinkage. When a brass or bronze casting is constrained, shrinkage in the constrained direction is generally very much less than normal shrinkage. Core or other inside dimensions, which are tied up with outside machining dimensions, should therefore not be laid out on the pattern with a shrinkage rule, but with a normal rule. The designer can aid in preventing errors of this kind by marking over-all machining dimensions of castings "Must be Exact," when it is really necessary that they should be exact.

# The Hardness of Copper Zinc Alloys

By Domenico Meneghim

IN ORDER to make determinations of hardness in order to ascertain the extent of cold working or of incomplete annealing, and being unable to utilize the classic method of Brinell, it occurred to the author to use a little apparatus operating under a slight pressure exercised by a ball of small diameter. Fig. 2 shows sufficiently clearly the arrangement of the apparatus. The pressure is brought to bear on the small piece of the alloy, which has plane and parallel surfaces, by a level along which weights can be moved. The steel ball, which will leave an imprint in the alloy, is fixed in a bronze cone. The specimen under examination must first of all be polished, and the imprint subsequently made by the pressure of the ball is afterwards measured under the microscope by means of a magnifying micrometer. For checking this apparatus, and for seeing if the superficial hardness had values comparable with those obtained from the apparatus of Brinell or of Shore, the author determined the hard-

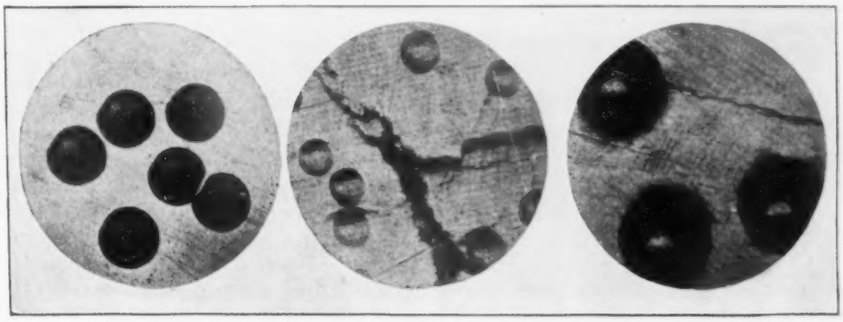


FIG. 1—HARDNESS IMPRESSIONS IN BRITTLE SPECIMENS OF THE SAME BRASS
The first specimen shows impressions in a sound portion. The second is a brittle fragment, and the hardness impressions are extremely irregular near the cracks. The third shows impressions after annealing, with a considerable dimunition of hardness. All are magnified 50 diameters. Their copper content is 64.1 per cent

From a paper read at the September meeting of the British Institute of Metals.

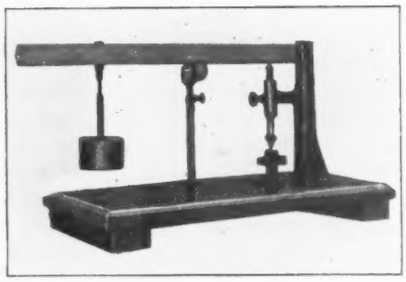


FIG. 2—INSTRUMENT FOR MAKING BRASS HARDNESS TESTS

ness of the copper-zinc alloys, of which there is in existence a complete diagram, given by Turner and Murray, obtained with the Brinell and Shore apparatus. The specimens were perfectly annealed, were then cut in pieces of about 70 millimeters in thickness. The alloys with zinc between 55 and 68 per cent were very hard and brittle, being most difficult to work.

Those alloys containing 78 to 88 per cent of zinc were in places very porous, and only in the case of samples containing 84 to 87 per cent of zinc was it found possible to obtain a specimen sufficiently homogeneous for making a hardness determination. The results are indicated as follows:

The determinations were made with a ball pressure of 10,870 kilograms (the diameter of the ball being 2.9 millimeters) in order to give an imprint lying between 0.280 millimeter and 0.570 millimeter. The superficial hardness is expressed as the ratio between the pressure exercised and the measured diameter of the imprint. For very hard alloys it was necessary to increase the pressure in order to obtain imprints lying between the values mentioned. In order to have all the hardness values stated for the same pressure, there were made for these very hard alloys three series of measurements at different higher pressures, and afterwards the diameter of the imprint at the normal pressure of 10,870 kilograms was worked out graphically. The diagram of superficial hardness is quite analogous to that given by Turner and Murray, only the first part of the diagram—that for brasses rich in copper—in less sinuous: perhaps that is due to the more perfect annealing of the specimens employed. It appears then that this very simple determination of superficial hardness can give in practice good results, which seem quite comparable with those obtainable with the much more costly apparatus, of Brinell and of Shore. This method has been utilized since for the study of gold-manganese alloys with very good results.

**Results of Hardness Tests**

| No. | Copper per cent | Zinc per cent | Diameter of Impression, Millimeters | Hardness $\delta = \frac{P}{d}$ † |
|---|---|---|---|---|
| 1 | 100.00 | ..... | 0.560 | 19.4 |
| 2 | 94.15 | 5.85 | 0.522 | 21.8 |
| 3 | 87.17 | 12.83 | 0.495 | 22.0 |
| 4 | 79.81 | 20.19 | 0.492 | 22.1 |
| 5 | 77.80 | 22.20 | 0.462 | 23.5 |
| 6 | 75.20 | 24.80 | 0.482 | 22.5 |
| 7 | 70.05 | 29.95 | 0.511 | 21.3 |
| 8 | 67.31 | 32.69 | 0.513 | 21.2 |
| 9 | 64.50 | 35.50 | 0.516 | 21.0 |
| 10 | 63.82 | 36.18 | 0.533 | 20.4 |
| 11 | 60.48 | 39.52 | 0.492 | 22.1 |
| 12 | 59.23 | 40.77 | 0.456 | 23.8 |
| 13 | 54.45 | 45.55 | 0.389 | 27.9 |
| 14 | 51.89 | 48.11 | 0.380 | 28.6 |
| 15 | 49.54 | 50.46 | 0.361 | 30.1 |
| 16 | 45.20 | 54.80 | 0.247 | 44.0 |
| 17 | 42.51 | 57.49 | 0.162 | 67.0 |
| 18 | 33.65 | 66.35 | 0.150 | 72.5 |
| 19 | 29.19 | 70.61 | 0.250 | 42.0 |
| 20 | 27.54 | 72.46 | 0.290 | 38.0 |
| 21 | 25.84 | 74.16 | 0.296 | 36.8 |
| 22 | 22.85 | 77.15 | 0.365 | 29.7 |
| 23 | 22.05 | 77.95 | 0.386 | 28.2 |
| 24 | 15.13 | 84.87 | 0.454 | 24.0 |
| 25 | 9.63 | 90.37 | 0.437 | 24.9 |
| 26 | 8.33 | 91.67 | 0.447 | 24.3 |
| 27 | 4.25 | 95.75 | 0.456 | 23.8 |
| 28 | 3.60 | 96.40 | 0.465 | 23.4 |
| 29 | .... | 100.00 | 0.685 | 15.9 |

# PROBLEMS OF THE BRASS FOUNDER

## *What To Do and How To Do It*

### Wax-Finishing Bronze

*We are completing a brass bank job which is to be wax-finished and we would like to know whether the wax is to be brushed or sprayed onto the surface. Also, is it necessary to heat the metal to impart this finish to the brass castings?*

In applying the wax finish, first warm the bronze and apply the wax with a brush so as to coat the surface of the metal with a thin protective film of wax. Care should be exercised to have all portions of the metal thoroughly coated. The bronze should be heated sufficiently to melt the wax. A bronze plaque, oxidized and coated with wax in this manner 15 years ago, has the same appearance today as when it was first finished.

### Refining the Grain of Brass

*We make a line of locomotive castings, but the grain of the metal seems to be very coarse. The principal contents of the castings analyze approximately as follows: Copper, 76 to 78 per cent; tin, 6 to 8 per cent, and lead, 14 to 16 per cent. A 700-pound heat consists of engine scrap, 623 pounds; clean scrap copper, 70 pounds; tin, 7 pounds, and 1 pound of phosphor-copper. We would like to know how to refine the grain of this mixture.*

The only way by which the grain of the metal can be improved is to resort to chilling the alloy, that is, by casting it in a permanent mold such as cast iron or steel. The effect is to check the crystal growth by reducing the time of its formation, which is afforded by slow cooling. If the permanent mold cannot be used, add 1 per cent of nickel to the alloy.

### Melting With Coal Screenings

*Can brass and other non-ferrous metals be melted successfully in a pit furnace with forced draft, using coal screenings?*

We doubt very much whether brass can be melted with coal screenings even with forced draft. If the blast is sufficiently strong to penetrate the fuel, it is possible that sufficient heat may be generated to melt satisfactorily, but this only can be determined by test.

### Tensile Strength of 88-10-2 Mixture

*What is the greatest possible obtainable tensile strength of a mixture containing 88 per cent copper, 10 per cent tin and 2 per cent zinc? What method should be followed to obtain this high tensile strength and at the same time secure sound castings?*

The greatest possible tensile strength that apparently can be obtained from an alloy consisting of copper, 88 per cent; tin, 10 per cent, and zinc, 2 per cent, is approximately 60,000 pounds per square inch, with an elongation of about 50 per cent. This tensile figure represents practically the high point, although from 52,000 to 53,000 pounds per square inch are frequently obtained with an elongation of 50 to 60.5 per cent. To obtain these high physical properties, it is essential to know how to melt the metal with the least possible amount of oxidation, what deoxidizer to use, to know how much of it to apply and when to add it to the mixture. This information is carefully guarded by manufacturers and is not easily obtained. Tests recently made on the 88-10-2

alloy by a number of concerns showed a tensile strength varying from 35,300 to 39,300 pounds per square inch, with an elongation of 10.5 to 13 per cent, which is much lower than the results previously given. However, this strength probably represents the average when the alloy is made without special treatment. The test bars should be cast to size and should be gated with a fin gate running along the side. To obtain sound castings, keep the metal well covered with charcoal while the melting operation is in progress.

## Oxides in Ingot Metal

*I have been having trouble with dirt on the outside of ingot metal castings of the following composition:* 85 *parts copper and* 15 *parts zinc, to which are added* 20 *pounds of yellow brass scrap and* 2 *pounds of lead. The dirt is on the outside of the castings and cannot be detected until the parts are machined. Can you advise us what causes this trouble?*

We believe that the addition of 1 per cent of phosphor-tin will greatly aid in insuring clean castings. As a rule, dirt in metal is produced by oxidation and in fact, it is a mixture of oxides of the metals comprising the alloy suspended in the same. The metal can be cleaned by the addition of some agent, such as phosphorus, which reduces oxides to metal by robbing them of their oxygen; these, in combination with the phosphorus, become a fusible slag and rise to the surface of the metal, from which they can be removed by skimming. Occasionally, however, when yellow brass is made by melting emery grindings, the small particles of emery are held in suspension in the alloy and the brass, when polished, displays black spots similar to those found in aluminum castings. In this case the metal should be melted hot under a cover of a fusible flux, such as fluorspar or soda ash, to remove the emery particles.

## Cheap Mixture for Locks

*Kindly give me a brass mixture suitable for locks, hinges and latches that must take a high polish. What is the cheapest mixture that can be used, still obtaining a red appearance? Also, I am having trouble with trap covers due to pin holes or slag. Can you advise me the cause of this difficulty?*

The following alloy will be satisfactory: Copper, 85 per cent; tin, 5 per cent; zinc, 5 per cent, and lead, 5 per cent. Trap covers are noted for their trouble-making properties. To correct the pinholes, add 0.25 per cent manganese copper.

## Color of Brass Castings

*Will you kindly let us know the mixture of the sample of yellow brass forwarded under separate cover and how the color on the back or unpolished surface is obtained? We use aluminum in our mixture and the metal has a gray color. We would prefer the color of the sample, but cannot produce good results without the use of aluminum.*

The color of the unfinished surface of the brass casting you mention is obtained by using a good grade of yellow brass free from aluminum. The same results can be obtained by using the following alloy: Copper, 70 per cent; zinc, 26 per cent; tin, 2 per cent, and lead, 2 per cent. This is a good grade of casting yellow brass and will produce much finer castings than the aluminum-treated metal, but it is a little more difficult to handle in the foundry.

## Flux for Small Brass Particles

*What is the best flux to use for melting small brass particles recovered from the cinder mill, magnetic separator, etc.? We would like to run this in ingot form.*

The following flux will be satisfactory: Lime, 10 per cent; powdered fluorspar, 30 per cent; salt, 10 per cent, and soda ash, 20 per cent. This will make a liquid slag which will cause the small metallic particles to sink to the bottom of the crucibles.

## Aluminum-Bronze Castings

*We have an order for aluminum-bronze castings containing* 90 *per cent copper and* 10 *per cent aluminum, but thus far, we have been unable to obtain the tensile strength required by the specifications. Our risers and gates swell and mushroom a short time after the metal is poured. Different materials have been used for slagging and deoxidizing, but the results show no improvement.*

As a casting proposition, aluminum bronze classes with such metals as copper, steel, nickel, nickel alloys and silicon-bronze, that is, it absorbs gases when molten and the castings are spongy unless the metal is treated with some element that has the power to remove these gases. The matter is complicated by the fact that the ordinary "deoxidizing" agents such as magnesium, vanadium, silicon, phosphorus, titanium, manganese, etc., that are efficacious in the case of the other metals and alloys mentioned, are quite powerless in the case of aluminum-bronze. The problem has been solved, however, and the method is in use by one manufacturer but cannot be given here. The use of the following precautions will materially assist in getting better castings. Melt the copper under charcoal; add a small portion of the aluminum first and note whether the surface of the metal becomes thick. If so, add a little salt and stir. This will act like zinc chloride on aluminum. Afterwards add the balance of the aluminum and if the metal is heated to incandescence, allow it to cool in the furnace to a normal temperature.

## Tobin Bronze Mixture

*Will you kindly give us a mixture for Tobin bronze, which will show an elongation of* 20 *per cent? We also have inquiries for bronze castings for gun carriages which must have a tensile strength of* 28,000, 35,000, 45,000 and 60,000 *pounds per square inch, respectively. No particular analyses are specified. Will you kindly give us formulas for bronze which will meet these requirements?*

For Tobin bronze make an alloy which will analyze as follows: Copper, 60.35 per cent; tin, 0.79 per cent; zinc, 38.85 per cent, and aluminum, 0.01 per cent. The elongation will vary from 30 to 40 per cent, depending upon how long the alloy is allowed to flare while in the furnace. Cast the first melt of metal into ingots and remelt it for castings.

An alloy containing copper, 80 per cent, and tin, 20 per cent, will meet all of the requirements of tensile strength mentioned in your inquiry except the 60,000-pound specification for which manganese bronze should be employed. An excellent formula for this was given on page 72 of the February, 1917, issue of *The Foundry*.

## Anti-Friction Metal

*We are experiencing some difficulty with babbitt metal which analyzes as follows: Lead,* 84 *to* 87 *per cent; antimony,* 12 *to* 14 *per cent, and tin,* 1 *to* 2 *per cent. The chemist who made this analysis claims that the mixture also contains a substance which he terms "black oxide of lead". We would like to know what effect this oxide will have on the metal, relative to its wearing qualities as a bearing for freight and passenger car service.*

If the alloy in question contains black lead in suspension, its bearing qualities will be greatly improved, as this substance will act as a lubricant. Black oxide of lead, however, is a substance that has been given little attention by chemists and metallurgists and some would even scoff at its existence. For freight and passenger car bearings, antomonial lead is most generally used as a lining metal. This alloy contains around 80 per cent lead and 20 per cent antimony. An excellent anti-friction metal is made as follows: Lead, 80 per cent; antimony, 15 per cent, and tin, 5 per cent.

# How Walker Process Reduces Ingot Mold Costs

## *Collapsible Core and Hinged Cheek Flask Play Important Part in Novel Method of Molding—Stripping and Shaking-Out Operations Simplified*

ON A par with the record-breaking steel production of the past 18 months has been the pressure on ingot mold foundries for castings. Many of these plants are allied departments of steel works, although it is estimated that more than 65 per cent of this tonnage is made in outside shops. Most of the ingot molds are poured from metal received direct from contiguous blast furnaces and in some instances these plants have a sufficient capacity to take the entire output from one or two stacks. A number of ingot mold shops remelt the iron in cupolas, this practice prevailing when it is impossible to obtain direct metal and when the direct metal is unsuited for these castings.

In the production of these bulky sections which aggregate a considerable percentage of the country's foundry production, the labor cost has been unusually high and every improvement in practice introduced in recent years has been directed toward the elimination of manual operations. Making cores for these large castings is a time-consuming operation and ramming the sand for the molds, in spite of the use of mechanically-driven rammers, is a back-breaking operation not favored particularly by molders, handy-men or laborers.

### *Recent Advances in Practice*

Several years ago a collapsible core for ingot molds was introduced which greatly facilitates the shaking-out of the castings and also the production of the core. With probably only one exception, the molds continue to be rammed by hand, due to the difficulties experienced in ramming them by machine.

In connection with its Ensley blast furnaces, steel works and rolling mills, the Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., operates a gray iron and steel foundry, the principal output of which, from a tonnage standpoint, consists of ingot molds. For a number of years these have been successfully rammed on a jar-ramming machine of the Mumford type, and this initial labor-saving operation was the forerunner of other experiments that had for their ultimate goal the production of the mold and core in one operation and the construction of all of the parts of the apparatus so that a crane or hoist can be employed in handling them. The only manual labor incident to the making of the mold and core and the shaking-out of the castings, involves the shoveling of the sand into the flask, and if sufficient headroom were available in this foundry, this operation could be eliminated by the installation of a sand chute.

The process was developed by J. B. Walker, superintendent of the pattern-shop of the Tennessee company

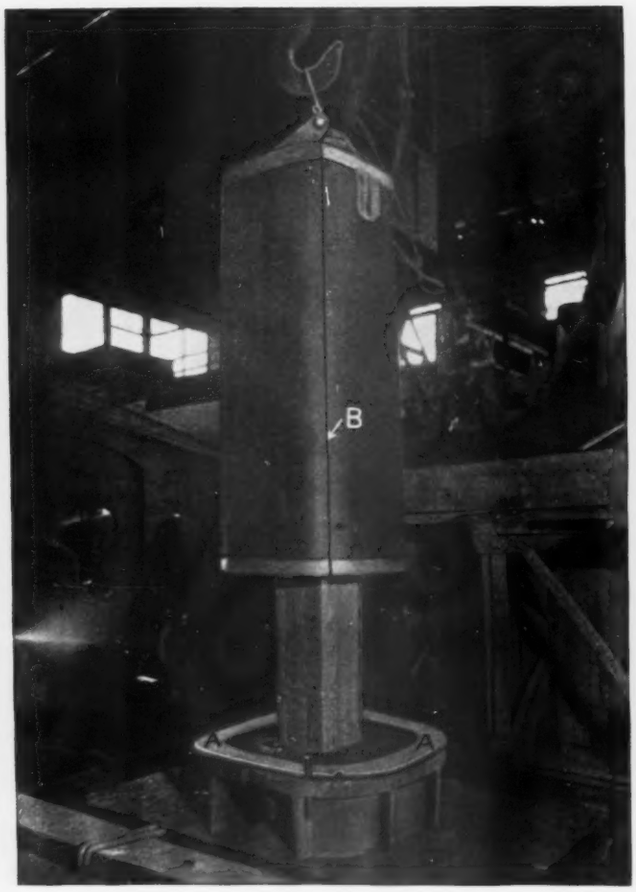



FIG. 1—LOWERING THE PATTERN OVER THE COLLAPSIBLE CORE ARBOR AND STOOL ON THE JAR-RAMMING MACHINE

FIG. 2—THE CAST STEEL CHEEK FLASK IN POSITION ON THE STOOL OR DRAG WITH THE STRIPPING PLATE BETWEEN

and involves the making of the mold and core in one operation on a molding machine of the jar or jolt-ramming type; the use of a collapsible core, special hinged flask, core arbor and stool, stripping plate and a hinged pattern which expands automatically thereby stripping freely from the sand core when lifted by a crane.

*Sequence of Operation*

Before describing the apparatus in detail, the sequence of operation entailed in assembling the flask, drawing the pattern, finishing and closing the mold, pouring and shaking-out will be presented. In the accompanying illustrations, the 40,000-pound jar-ramming machine is shown in Figs. 1 and 2. The core arbor and stool, with pattern being lowered into position, are illustrated in Fig. 1. On the parting surface of the stool is shown the stripping and lifting plate, *A*, which is centered by pins passing through holes in diagonal sides of the stool. The core arbor and stool constitute the drag section of the flask. The pattern is hinged at the top, being split across diagonal corners, as at *B*, thereby leaving it free to expand when it is being lifted off the core by a crane or hoist. The cheek section of the flask is shown lowered onto the drag or stool, in Fig. 2. The stripping plate is clamped to the cheek on two opposite sides, while the cheek is clamped to the stool, on the remaining two sides. The cheek flask consists of two parts hinged at the top. The bearing surfaces of the halves are brought together by the rope sling on the crane which loops over lugs or trunnions, *A*, Fig. 2, located on either side of the flask. When brought together by the crane, the two halves are locked by U-shaped clamps, *B*, Fig. 2. The lugs, *C*, two on each half of the cheek flask, are engaged by the crane sling when shaking-out the casting, Fig. 5, to effect the spreading of the two halves of the cheek and bolt, *D*, Fig. 2, has been provided to limit the distance of opening.

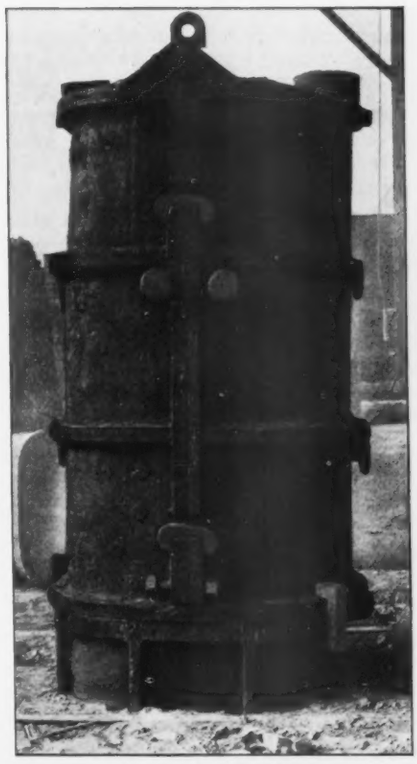
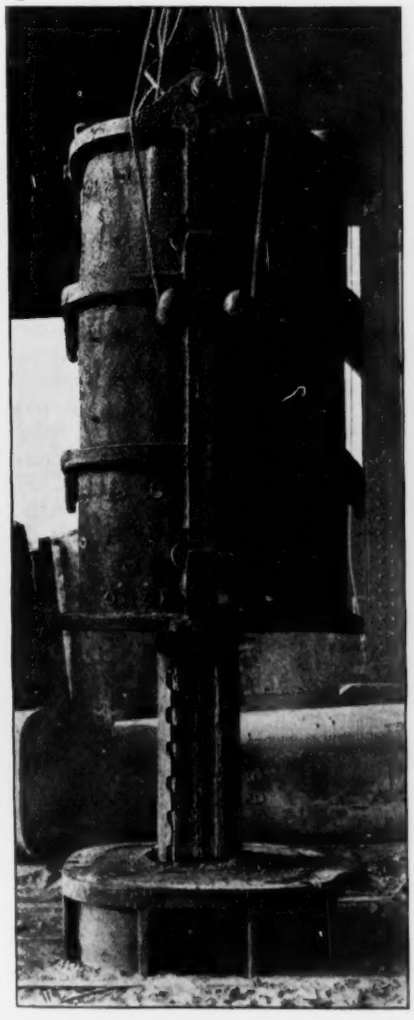


FIG. 3 — THE INGOT MOLD POURED AND READY TO BE SHAKEN-OUT

*Collapsible Core*

The pattern is centered on the stool by the stripping plate and it is prevented from spreading by the bank of sand which packs around it after the initial jar-ramming operation. Before sand is filled into the flask, the collapsible core is expanded by a key at the top. Sand continues to be shoveled into the flask throughout the ramming operation on the machine, which consumes from 10 to 12 minutes. After the mold and core are rammed, sand is shoveled out of the mold top on two sides and the two loose parts of the pattern which make the ingot mold lugs are attached to the pattern body by a tongue and groove, and the sand is packed around them by hand. One of the difficulties heretofore experienced in making ingot molds on a jar-ramming machine has been the inability to properly pack the



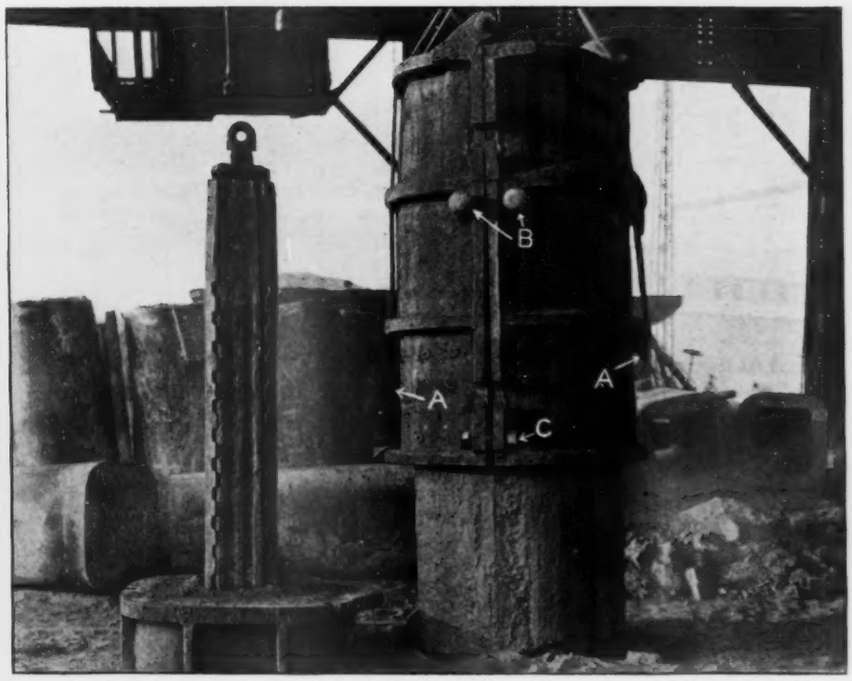



FIG. 4 (At the Left)—AFTER COLLAPSING THE CORE ARBOR, THE CHEEK FLASK CONTAINING THE CASTING IS LIFTED OFF BY CRANE—
FIG. 5—THE HINGED CHEEK FLASK HAVING BEEN EXPANDED, IS READILY LIFTED OFF

sand around these parts of the pattern. The sand underneath the lugs invariably was soft and rammed-off, causing an imperfect coating. However, by inserting the pattern lugs after the ramming operation has been completed, the sand underneath the surface of the lugs is of the proper density and all previous difficulties have been overcome. The runner, which is a 3-inch steel bar, is withdrawn by the crane before the flask is removed from the machine table.

*Casting Pit Operation*

From the jar-ramming table the mold is transferred to the casting pit by crane where the pattern is drawn and the cheek and core are skin-dried and sprayed with blacking, after which they are assembled for pouring. After removing the clamps which hold the cheek and the drag, the cheek is stripped over the pattern which is held down by a special device to overcome the great pressure of so large a body of sand on such an extensive pattern area. In the meantime the stripping plate continues to be clamped to the cheek, but when the cheek part of the mold is stripped from the pattern, the latter being hinged at the top is free to expand at the bottom and it opens at two diagonal corners. The pattern is next drawn from the core by the crane. In the meantime another stool and core arbor have been placed on the table of the jar-ramming machine and the pattern is lowered into position for preparing another mold. Whatever finishings on the cheek and core are necessary are performed in the pit, after which they are sprayed with blacking and skin-dried. The drying continues for a period of about 12 hours and before the mold is assembled and closed, the stripping plate is removed. A gate, 3 inches in diameter, is cut at the bottom of the runner by the molder who does the finishing. A pouring basin is set on top of the mold, the metal entering through one gate only, at the bottom.

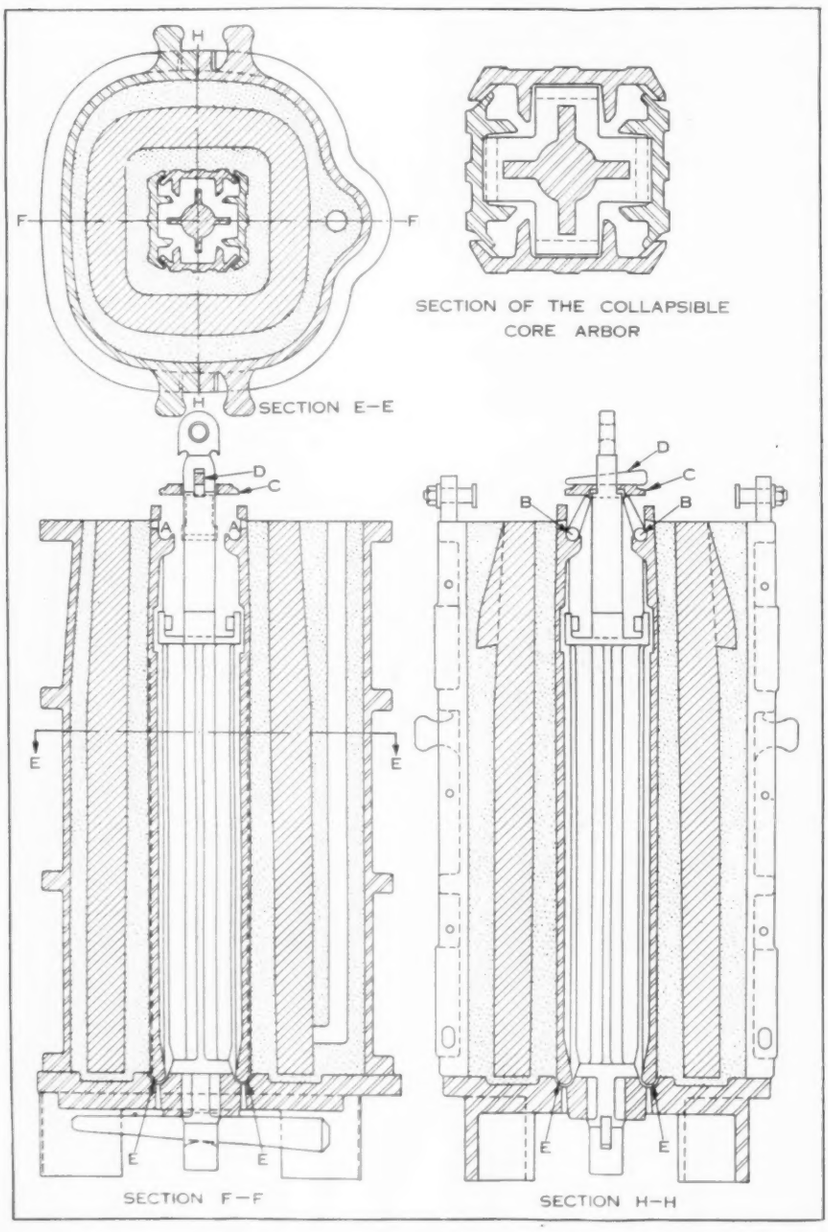



FIG. 6—HORIZONTAL AND VERTICAL SECTIONS OF THE ASSEMBLED APPARATUS AND HORIZONTAL SECTION OF THE COLLAPSIBLE CORE ARBOR

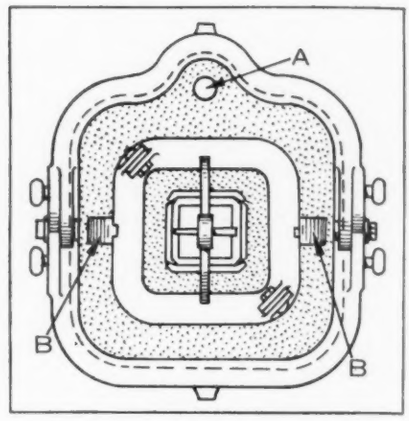



FIG. 7—TOP PLAN VIEW OF THE ASSEMBLED APPARATUS

*Shaking-Out*

After the mold has been poured, it is conveyed by crane from the pit to the shaking-out floor, Fig. 3. The rope slings on the crane pass over the trunnion lugs on either side of the flask, Fig. 4, which shows the first step in the shaking-out operation. Prior to removing the cheek flask, the key at the top of the core arbor by which it was expanded, was punched out, thereby permitting the arbor to collapse and making it possible to lift the cheek from the arbor. In Fig. 5, the arbor collapsed and the stool are shown at the left. At the right the cheek flask is being stripped from the casting, leaving the sand adhering to the outside of the ingot mold, the same as the sand of the core remains inside of the mold when stripped over the core arbor. By permitting the casting to remain surrounded with the core and molding sand until it cools, it becomes thoroughly annealed, which has been found to be a particularly desirable operation for ingot molds, materially increasing their period of usefulness.

When stripping the hinged cheek flasks from the mold, the crane sling engages the opening lugs at *A*, Fig. 5, *B* being the closing lugs or trunnions. The U-shaped clamps previously have been removed and

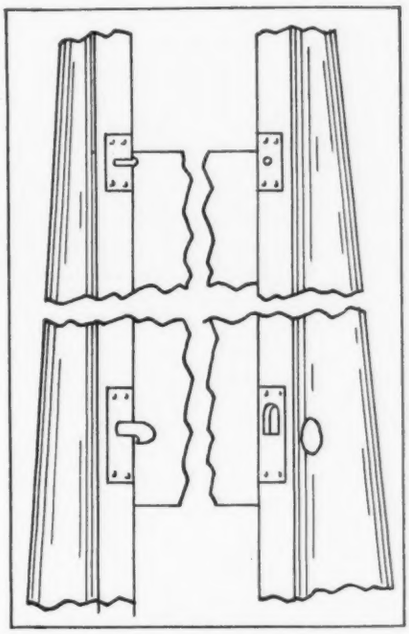


FIG. 8—DETAIL OF THE TOP OF THE EXPANSIBLE CORE ARBOR

the lateral action of the slings permit the flask to open the distance provided by the bolt *C*.

In Fig. 6 are shown vertical and horizontal sections of the assembled apparatus, with a section through the core arbor. The arbor is formed by four collapsible staves which carry at their upper ends internal socket bearings, *A*, Fig. 6, in which pawls, *B*, are mounted free to rock, being disposed upwardly so as to engage the column of the arbor at a point above the top of the staves. The staves have lapping corner joints, as illustrated in the section of the arbor, Fig. 6, and their construction also is clearly shown in Fig. 12. The staves are expanded by the action of the plate, *C*, and the wedge key, *D*, on the column, which engages the pawls and forces the staves outwardly until arrested by the engagement of the lugs on the staves with stop lugs on the column. At their lower ends, the staves are mounted to rock in the sockets, *E*, on the stool drag. The stool is recessed in its upper face to form the drag portion of the mold.

An elevation of the flask broken away to show the edge of the pattern and illustrating the sand band for holding it contracted during the ramming operation, is illustrated in Fig. 9. The pattern is divided diagonally in a vertical plane and each section carries about its top a protecting plate with upturned, perforated lugs at each end, arranged

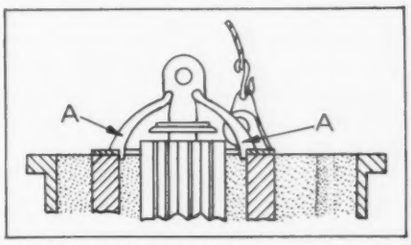



FIG. 10—DETAIL VIEW OF THE APPARATUS FOR HOLDING DOWN THE PATTERN AND THE METHOD OF APPLYING THE CRANE HOOKS TO THE PATTERN

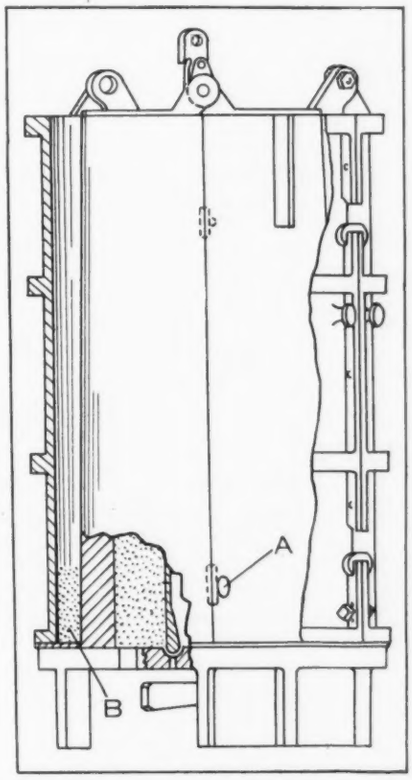



FIG. 9 — ELEVATION OF THE FLASK BROKEN AWAY TO SHOW EDGE OF PATTERN AND SAND BAND FOR HOLDING IT CONTRACTED

to overhang so that their holes, when in register, will lie in the plane of parting between the pattern sections. Between each pair of lugs is interposed a hanger plate which is on the same bolt that pivotally connects the lugs. The upper ends of these plates have holes to receive the hooks of the crane. The two holes of the pattern are centered by dowel pins and the expanding movement of the two sections is limited by an ingenious arrangement of hooks at *A*, Fig. 9, and shown in detail in Fig. 11. The encircling sand band is to hold the pattern contracted, as illustrated at *B*, Fig. 9. When ramming a mold, sand first is shoveled between the pattern and the flask to a height of about a foot. The table is given three or four jolts which compact the sand around the pattern and force and hold together the free ends of the section.

Fig. 7 is a top plan of the assembled apparatus showing the gate at *A* and the detached lug patterns at *B*. As stated previously, it is practically impossible to pack the sand around these lugs by the jolting or jarring process, and this mold and core are rammed

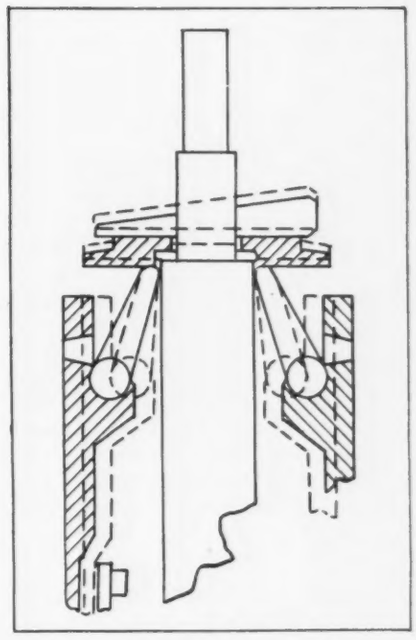


FIG. 11—DETAIL OF THE PATTERN DOWELS AND HOOKS

before the ingot mold lugs are attached to the pattern. The operator removes the packed sand from the top of the pattern when the lugs are to be attached and inserts the lug patterns into vertical slots in the pattern which engage tongues in the lugs. The lug patterns are stripped off with the cheek and are drawn as a part of the finishing operation. A review of the device used

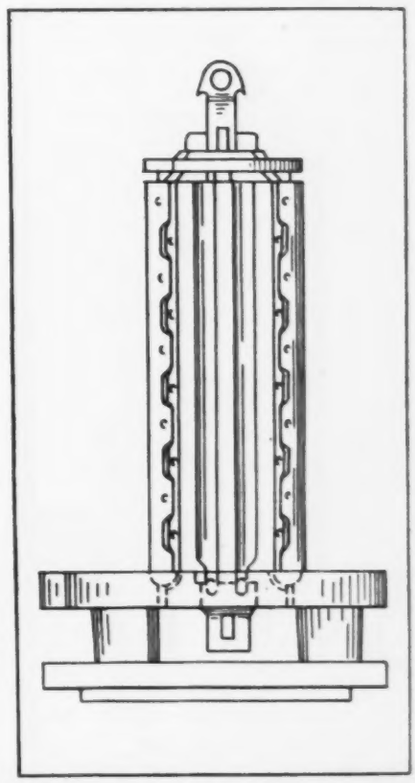


FIG. 12—THE CORE ARBOR SHOWING THE CONSTRUCTION AND ARRANGEMENT OF THE PLATES

for holding down the pattern when drawing the cheek and the manner of applying the crane hooks to the pattern, is illustrated in Fig. 10. Bars, *A*, are inserted between the lugs of the arbor column and the inner wall of the pattern and prevent it from moving upwardly when the cheek is being stripped from the stool, drag and pattern.

The Tennessee Coal, Iron & Railroad Co. uses unusually large ingots in its blooming mill. These are 24 x 24 inches and weigh approximately 10,500 to 11,000 pounds. The entire flask equipment, core arbor, etc., necessarily must be very heavy and when ready to pour, the mold for the ingot mold weighs 21,200 pounds. The flasks are cast steel and are made in this foundry. The coring of vent openings in the flasks has been eliminated by the arc-welder, which burns these holes in the flasks much more speedily than the cores can be set in the mold. The ingot mold core is thoroughly vented through the plates, the gases being carried off at the top. Green sand, tempered with water only, is used for both mold and core. Twelve molds are made daily by a gang of 10 men consisting of the following: Six laborers, one rammer, two finishers and one man who closes the molds and pours the castings.

One of the great difficulties that had to be overcome in successfully adopting the jar-ramming operation to the production of these large molds, was the prevention of the movement of the flask on the table of the machine. After careful investigation it was ascertained that this was caused by the leakage of air between the piston and the anvil of the machine which imparted a slight tilting motion to the table. A male and female joint were machined on the two surfaces which are thoroughly packed, thereby preventing the leakage of air and all creepage of the flasks has thereby been eliminated.

### *The Ingot Mold Mixture*

The metal made by the Tennessee company's blast furnaces is not adapted for use in ingot molds, and, therefore, the direct process is superseded by the cupola method. The mixtures are made in a 54-inch furnace which is driven continuously from about 8 a. m. until 4 p. m. The heats vary from 75 to 80 tons, and considering the diameter of the lining the practice is unusual. However, the method of charging is so controlled and fluxes are used so judiciously, that a hang practically never occurs. The metal used for ingot molds has the following analysis: Silicon 1.5 per cent; sulphur, 0.06 per cent; phosphorus, 0.2 to 0.3 per cent, and manganese, 0.60 to 0.65 per cent. The life of these molds varies from 75 to 90 heats.

## The Pattern Maker of the Hour

*By Joseph Goostray*

Many problems enter into pattern-making which give ground for careful consideration and exceptional opportunities for careful study. It is a trade requiring not only the ability to read mechanical drawings and a knowledge of the durability of woods and the ease with which they are pared and worked, but also a thorough understanding of foundry practice.

Foundry practice is such a comprehensive study that a knowledge of it in its entirety cannot be demanded of a patternmaker. However, it is proper to insist that he be thoroughly familiar with the process of molding and core-making. There are a few points which should be emphasized and constantly kept in mind because of their significance in the relation of pattern-making to foundry practice.

Satisfactory patterns are necessary for efficient molding and they should always be constructed to effect the greatest economy in the foundry. It is doubtful whether the average foundryman realizes to what extent a patternmaker can go in the construction of cheap patterns. The patterns may perhaps meet requirements and a careful inspection may show the dimensions are accurate. The critical question, however, is whether the patterns afford facility of operation for the molder. The construction of a pattern with the view of the best methods of molding it should be one of the first considerations. A properly constructed pattern will save a lot of unnecessary work and expense in the foundry to say nothing of the subsequent delay in the production of castings.

Few patternmakers are familiar enough with molding and core-making to realize the problems which confront the molder and coremaker. Unfortunately many patternmakers do not know whether a pocket or hanging portion of sand will stand of its own accord. If the molder is forced to secure parts which could be easily formed by a core, his operations are considerably delayed. Special care should be exercised by the patternmaker to eliminate difficulties that might enter into the making of a mold. Such knowledge is only acquired by observing the consequences of molding a particular pattern. A patternmaker should keep in touch with what is being done in the way of improved molding methods. This is necessary if the pattern shop is to serve its best interests in its relation to the foundry, but it is very much more important to the patternmaker as a means of broadening his views and knowledge of foundry practice. Too much emphasis cannot be placed on the absolute necessity of a patternmaker going into the foundry and making an honest and efficient effort to observe the methods used in molding and coremaking. Only in this way can he gain an insight into the attendant problems of molding and core-making. Knowledge gained through experience brings with it conviction.

There is also a tendency among patternmakers to confine their study of machines to those used in making patterns. This tendency is decidedly wrong, for a patternmaker cannot do his best work unless he is familiar with molding machines. He should study the adaptability of these machines for he can assist materially in promoting their efficiency and usefulness. His patterns should be constructed after a careful study of the various machines so that the limit of output may be attained when the pattern goes into the foundry. The argument that a pattern must be tried out is weak. Notwithstanding the points that may be advanced to substantiate the argument, it has been proved beyond a doubt that a properly constructed pattern needs no special foundry trial to determine whether it can be molded to its best advantage.

Furthermore no patternmaker can accomplish much without a thorough knowledge of the applications of cores. Many distinct advantages may be secured, and the appearance of a casting greatly improved by the application of cores. It is essential for a successful patternmaker to be thoroughly acquainted with this phase of foundry work.

An endeavor to find a simple definition of the application of cores results as follows: Cores are used to form the portion of a casting which is not determined by the pattern or in many instances they are used to form the whole of the casting.

How much of the casting shall be formed by cores and how much by the pattern cannot be determined by any definite rule, but is a question to be decided by a constant study of the methods employed in making castings of this nature. Experience and observation are necessary to determine the question but books are admirable adjuncts. Of course mere reading in itself would never make a patternmaker, any more than reading without actual experience would make a practical man in any field of work. But the patternmaker who carefully reads and studies journals pertaining to the foundry is far more apt to be able to determine this question than if he had not. Through reading he will not be so liable to fall into the error of thinking his is the only and best way to accomplish the required results. Undoubtedly he will gain through reading the experience of others who have had a similar problem to solve.

# Recommends Standard Screen Scale for Sieves

***Bureau of Standards Announces Scale Based Upon Ratios of Square and Fourth Roots of Two—Proposed for General Adoption***

AS THE result of investigations and conferences held over a period of several years, the bureau of standards has announced a standard screen scale for testing sieves. The standard has been adopted by a conference of representatives of government bureaus, private firms and various scientific and technical societies including the American Foundrymen's Association and American Institute of Metals. The standard scale is recommended for general adoption in the interests of securing uniformity of usage.

The screen scale is essentially metric. A sieve having an opening of one millimeter is calculated as a basis of the system. The sieves above and below this in series are related to it by using the square root of two (1.4142) or the fourth root of two (1.1892) as a ratio of the width of one opening to the width of the next smaller opening. The ratio is used for openings between one and eight millimeters, while the fourth root of two is used for the ratio of openings below one millimeter.

The bureau of standards announces that it will test sieves to determine whether they conform to the specifications covering the new standard. The cost of testing ranges from $1 to $2 per sieve, depending on the number of sieves submitted for examination at one time. Only one-half of the fee is charged for examining sieves which are rejected for exceeding tolerances of mesh.

The specifications for sieves conforming to the standard screen scale are as follows:

Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of 0.062-millimeter, the 0.052-millimeter, and the 0.044-millimeter sieve, may be twilled until further notice), from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch.

The number of wires per centimeter of the cloth of any given sieve of the standard screen scale shall be that shown in the accompanying table in the column headed "Mesh", and the number of wires in any whole centimeter shall not differ from this amount by more than the tolerance given in the column headed "Mesh" under the heading "Tolerances". No opening between adjacent parallel wires shall be greater than the nominal width of opening for that sieve by more than the following amounts:

10 per cent of the nominal width of opening for the 8 to the 1-millimeter sieve, inclusive.

25 per cent of the nominal width of opening for the 0.85 to the 0.29-millimeter sieve, inclusive.

40 per cent of the nominal width of opening for the 0.25 to the 0.125-millimeter sieve, inclusive.

60 per cent of the nominal width of opening for the 0.105 to the 0.044-millimeter sieve, inclusive.

The diameters of the wires of the cloth of any given sieve shall be those shown in the column headed "Wire Diam." and the average diameter of the wires in either direction shall not differ from the specified diameter by more than the tolerance given in the last column under "Tolerances" headed "Diam."

The bureau of standards also reserves the right to reject sieves for obvious imperfections in the sieve cloth or its mounting, as, for example, punctured, loose or wavy cloth, imperfections in soldering, etc.

Until further notice, to permit the use of sieves now on the market which have slightly different mesh and wire diameters from that specified above, sieves will be certified as satisfactory if the measurements of mesh and wire diameters show the resulting average width of opening to be within 4 per cent of the

## Proposed Standard Screen Scale for Sieves

Dimensions for metric scale are given in millimeters; those for customary scale are given in inches

| Standard | Opening | Mesh | Wire diam. | Ratio Wire diam. to opening | Tolerances (plus or minus) Mesh | Tolerances (plus or minus) Diam. |
|---|---|---|---|---|---|---|
| 8-mm Sieve: | | | | | | |
| Metric ..... | 8.00 | 1.0 | 2.00 | 0.25 | 0.01 | 0.08 |
| Customary... | 0.315 | 2.54 | 0.079 | .... | 0.03 | 0.003 |
| 5.66-mm Sieve: | | | | | | |
| Metric ..... | 5.66 | 1.4 | 1.48 | 0.26 | 0.01 | 0.08 |
| Customary... | 0.223 | 3.56 | 0.058 | | 0.03 | 0.003 |
| 4-mm Sieve: | | | | | | |
| Metric ..... | 4.00 | 2.0 | 1.00 | 0.25 | 0.02 | 0.05 |
| Customary... | 0.157 | 5.1 | 0.039 | | 0.05 | 0.002 |
| 2.8-mm Sieve: | | | | | | |
| Metric ..... | 2.83 | 2¼ | 0.81 | 0.29 | 0.02 | 0.05 |
| Customary... | 0.111 | 7.0 | 0.032 | | 0.05 | 0.002 |
| 2-mm Sieve: | | | | | | |
| Metric ..... | 2.00 | 3.9 | 0.56 | 0.28 | 0.04 | 0.05 |
| Customary... | 0.079 | 9.9 | 0.022 | | 0.1 | 0.002 |
| 1.41-mm Sieve: | | | | | | |
| Metric ..... | 1.41 | 5.0 | 0.59 | 0.42 | 0.08 | 0.025 |
| Customary... | 0.0555 | 12.7 | 0.0232 | | 0.2 | 0.0010 |
| 1.0-mm Sieve: | | | | | | |
| Metric ..... | 1.00 | 7.0 | 0.43 | 0.43 | 0.15 | 0.020 |
| Customary... | 0.0394 | 17.8 | 0.0169 | | 0.4 | 0.0008 |
| 0.85-mm Sieve: | | | | | | |
| Metric ..... | 0.85 | 8.0 | 0.40 | 0.47 | 0.2 | 0.015 |
| Customary... | 0.0335 | 20.3 | 0.0157 | | 0.5 | 0.0006 |
| 0.71-mm Sieve: | | | | | | |
| Metric ..... | 0.71 | 9.0 | 0.40 | 0.56 | 0.3 | 0.012 |
| Customary... | 0.0280 | 22.9 | 0.0157 | | 0.75 | 0.0005 |
| 0.59-mm Sieve: | | | | | | |
| Metric ..... | 0.59 | 10.0 | 0.41 | 0.69 | 0.4 | 0.012 |
| Customary... | 0.0232 | 25.4 | 0.0161 | | 1.0 | 0.0005 |
| 0.5-mm Sieve: | | | | | | |
| Metric ..... | 0.50 | 12.0 | 0.33 | 0.66 | 0.4 | 0.012 |
| Customary... | 0.0197 | 30.5 | 0.0130 | | 1.0 | 0.0005 |
| 0.42-mm Sieve: | | | | | | |
| Metric ..... | 0.42 | 14.0 | 0.29 | 0.69 | 0.6 | 0.010 |
| Customary... | 0.0165 | 35.6 | 0.0114 | | 1.5 | 0.0004 |
| 0.36-mm Sieve: | | | | | | |
| Metric ..... | 0.36 | 16.0 | 0.26 | 0.72 | 0.6 | 0.010 |
| Customary... | 0.0142 | 40.6 | 0.0120 | | 1.5 | 0.0004 |
| 0.29-mm Sieve: | | | | | | |
| Metric ..... | 0.29 | 20.0 | 0.21 | 0.72 | 0.8 | 0.010 |
| Customary... | 0.0114 | 50.8 | 0.0083 | | 2.0 | 0.0004 |
| 0.25-mm Sieve: | | | | | | |
| Metric ..... | 0.25 | 23.0 | 0.185 | 0.74 | 1.0 | 0.008 |
| Customary... | 0.0098 | 58.4 | 0.0073 | | 3.0 | 0.0003 |
| 0.21-mm Sieve: | | | | | | |
| Metric ..... | 0.21 | 27.0 | 0.16 | 0.76 | 1.0 | 0.008 |
| Customary... | 0.0083 | 68.6 | 0.0063 | | 3.0 | 0.0003 |
| 0.17-mm Sieve: | | | | | | |
| Metric ..... | 0.17 | 31.0 | 0.15 | 0.88 | 1.0 | 0.008 |
| Customary... | 0.0067 | 78.7 | 0.0059 | | 3.0 | 0.0003 |
| 0.14-mm Sieve: | | | | | | |
| Metric ..... | 0.14 | 39.0 | 0.116 | 0.83 | 1.0 | 0.008 |
| Customary... | 0.0055 | 99.1 | 0.0046 | | 3.0 | 0.0003 |
| 0.125-mm Sieve: | | | | | | |
| Metric ..... | 0.125 | 47.0 | 0.089 | 0.71 | 1.5 | 0.008 |
| Customary... | 0.0049 | 119.4 | 0.0035 | | 4.0 | 0.0003 |
| 0.105-mm Sieve: | | | | | | |
| Metric ..... | 0.105 | 59.0 | 0.064 | 0.61 | 2.0 | 0.008 |
| Customary... | 0.0041 | 149.9 | 0.0025 | | 5.0 | 0.0003 |
| 0.088-mm Sieve: | | | | | | |
| Metric ..... | 0.088 | 67.0 | 0.061 | 0.69 | 2.5 | 0.005 |
| Customary... | 0.0035 | 170.2 | 0.0024 | | 6.0 | 0.0002 |
| 0.074-mm Sieve: | | | | | | |
| Metric ..... | 0.074 | 79.0 | 0.053 | 0.72 | 3.0 | 0.005 |
| Customary... | 0.0029 | 200.7 | 0.0021 | | 8.0 | 0.0002 |
| 0.062-mm Sieve: | | | | | | |
| Metric ..... | 0.062 | 98.0 | 0.040 | 0.65 | 3.5 | 0.005 |
| Customary... | 0.0024 | 248.9 | 0.0016 | | 9.0 | 0.0002 |
| 0.052-mm Sieve: | | | | | | |
| Metric ..... | 0.052 | 110.0 | 0.039 | 0.72 | 4.0 | 0.004 |
| Customary... | 0.0021 | 279.4 | 0.0015 | | 10.0 | 0.00015 |
| 0.044-mm Sieve: | | | | | | |
| Metric ..... | 0.044 | 127.0 | 0.035 | 0.80 | 5.0 | 0.004 |
| Customary... | 0.0017 | 323.0 | 0.0014 | | 12.0 | 0.00015 |

nominal opening of the given sieve, and the ratio of wire diameter to opening of the sieve in question is within 0.03 of that given in the column headed "Ratio Wire Diam. to Opening" for the 8 to the 2-millimeter sieves, inclusive, and within 0.06 of the ratio given for sieves of smaller openings than 2 millimeters.

Provision has been made for interpolating between screens of 8.0 to 1.0-millimeter openings by using the fourth root of two as the ratio of successive sieve openings. This would provide sieves of the following openings: 1.19, 1.68, 2.38, 3.36, 4.76 and 6.72-millimeter.

To provide for sieves of larger openings the screen scale could be extended from the 8-millimeter size in the accompanying table to 128 millimeters. Such an addition to the scale would provide sieves of the following sizes, based on the ratio of the square root of two; 11.3, 16.0, 22.6, 32.0, 45.3, 64.0, 90.5 and 128.0-millimeter.

## Casting Production in 1916

From figures compiled by the American Iron and Steel Institute, covering the total pig iron production in 1916, a fair estimate can be obtained of the casting production of the United States last year. The production of foundry iron reached the enormous total of 5,553,644 tons, to which 921,486 tons of malleable iron must be added. It is difficult, of course, to estimate the casting production for 1916, since no statistics are gathered covering this industry. The high consumption of scrap is a factor which must be considered in this total, but it can be estimated safely that the total casting production last year was well in excess of 7,000,000 tons. With the malleable pig iron production approaching the million-ton mark, the growth of the malleable industry can fairly well be gaged. The 1916 production of foundry iron increased 14 per cent over that of 1915.

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Oliver J. Abell has resigned as western editor of *The Iron Age* to engage in business for himself as a manufacturer's agent, with offices in the Sharples building, 565 Washington boulevard, Chicago. Mr. Abell will specialize on equipment for handling material and the transmission of power, including a full line of chain for elevating, conveying and power-drive purposes. Mr. Abell is a graduate of Case School of Applied Science, Cleveland, and has had extensive experience in trade journalism and in the iron and steel business. He is a member of the Chicago Foundrymen's Club, American Foundrymen's Association and the American Iron & Steel Institute.

# The Use of Cast Iron Molds and Cores

By Paul R Ramp

CAST IRON cores and molds frequently effect great economies in core-making and molding. Some foundrymen, however, do not consider this method of molding favorably and for this reason the use of cast iron cores and molds is not extensive. Unfortunately, cast iron cores are not always properly used. An iron core should not be used in parts of molds where the metal will hold it so firmly that it will have to be driven out of the casting. It is also inadvisable to use a cast iron mold for making castings that are to be machined, unless a low chilling iron is used. To produce castings in permanent molds means must be provided for removing them from the molds as speedily as possible. The joints of the mold should also be kept clean and these joints should be machined to prevent the formation of fins. The permanent mold effects undoubted economies and many sections now cast in sand could be produced in this way. Cast iron cores can be used extensively, except in such sections of molds that contain projections that will hold the core. In the accompanying illustrations the use of cast iron cores and molds for various castings is shown. Two views of a locomotive grate frame are illustrated in Fig. 1. In ordinary practice cores are used to form the journals, *B*, as well as the bearings for the rocker grate, *C*. Unless great care is exercised in making these cores, both bearings will be unusually rough. By the use of cast iron cores at these points, smooth surfaces can be obtained and as they are chilled they can be subjected to considerable wear. The lug, *E*, Fig. 1, is generally formed by a large core which extends down from the upper part of the pattern. This core is expensive to manufacture and considerable trouble is frequently experienced in holding it in place, as it

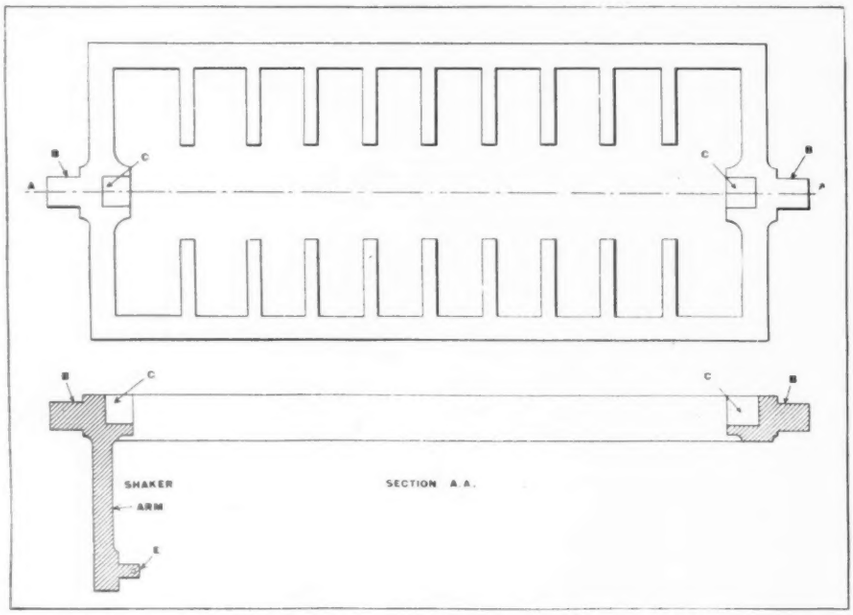


FIG. 1—PLAN VIEW AND LONGITUDINAL SECTION OF A LOCOMOTIVE GRATE FRAME

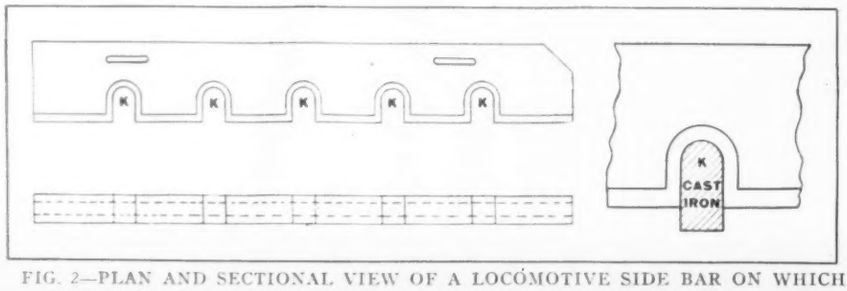


FIG. 2—PLAN AND SECTIONAL VIEW OF A LOCOMOTIVE SIDE BAR ON WHICH CAST IRON CORES WERE USED FOR FORMING THE BEARING SURFACES

cannot be readily secured at the bottom. A cast iron core at this point will effect great economies in the manufacture of these castings. Sectional views of the iron mold which forms this lug are illustrated in Fig. 3. The mold is held together by pins and at *G* is shown a small dry sand core which forms the hole for the key for adjusting the shaking bar to the lug. This cast iron mold was made at a small cost and the joints were not machined as the iron mold is held in position by the sand.

Fig. 4 is a cross-section of a portion of the mold for this grate bar and shows the cast iron mold for the journal and the iron core for the bearing. The various parts of the mold are located by prints on the pattern, the same as when sand cores are used. Fig. 2 illustrates plan and sectional views of a locomotive side bar casting. The openings, *K*, are bearings upon which the journal of the grate frame rests. These bars are usually formed by dry sand cores, but better results are obtained with cast iron cores. These cores insure smooth bearing surfaces and effect economies in core-making.

## Does Copper Affect Shrinkage of Steel Castings?

*By G. E. Jones*

*Question:*—Why does one brand of pig iron give satisfactory results in a side-blow converter and another brand of the same composition, excepting copper, give metal that shrinks excessively before cooling? In our experience the metal that does not contain copper drains the sinkheads. The composition of the two kinds of iron is as follows: Non-shrinking copper-bearing pig, carbon, 3.74 per cent; silicon, 3.02 per cent; sulphur, 0.016 per cent; phosphorus, 0.03 per cent; manganese, 0.13 per cent; titanium, 0.15 per cent, and copper, 0.60 per cent. Copper-free pig, carbon, 3.46 per cent; silicon, 2.91 per cent; sulphur, 0.012 per cent; phosphorus, 0.042 per cent; manganese, 0.11 per cent, and titanium, 0.41 per cent.

We are using a recarburizer of the following composition: 11 per cent ferro-silicon, 70 pounds; 80 per cent ferro-manganese, 40 pounds; cupola iron, 30 pounds; aluminum, 1 pound; and 25 per cent ferro-titanium, 8 pounds. Can this recarburizer be improved upon in making castings containing about 0.21 per cent carbon? The heats are made in a 2-ton, side-blow converter. The ferro-silicon and ferro-manganese are heated to redness in a ladle, the cupola iron is added and after about one-third of the steel is in the ladle, the aluminum and titanium are thrown in.

*Answer:*—The presence of copper in steel-making pig iron will tend to reduce the shrinkage, especially when it is present in large quantities. This is due to the fact that copper shrinks less than steel and in combination imparts its characteristic to the alloy. On the other hand, 0.60 per cent copper is not sufficient to make any appreciable

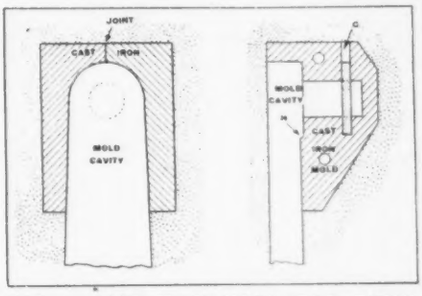


FIG. 3—CAST IRON MOLD FOR FORMING THE LUG OF THE LOCOMOTIVE GRATE FRAME

difference in the shrinkage. Tests on heats ranging in copper from nothing to 1 per cent have indicated that there is not sufficient decrease in the shrinkage due to this amount of copper to warrant consideration.

With reference to recarburizing, there are many ways of making additions. The most accurate method is to add all of the recarburizers in molten form. Such a procedure, however, is too expensive where only a small tonnage is required, and in such cases the ferro-silicon and ferro-manganese may be added cold in the vessel. It is not advisable to add them in the ladle, as the preliminary reaction of ferro-silicon and ferro-manganese should be complete before the other deoxidizers are added. The addition of aluminum and titanium in the ladle is good practice. The

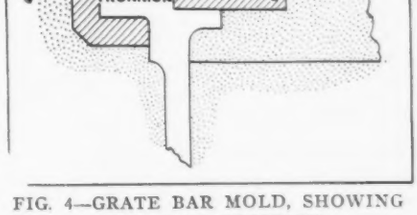


FIG. 4—GRATE BAR MOLD, SHOWING CHILLS IN POSITION

writer, however, would suggest a reduction in the amount of aluminum and an increase in the proportion of titanium for the reason that aluminum may leave traces of alumina in the steel. The amount of manganese you mention is correct, but 70 pounds of 11 per cent ferro-silicon would not give the correct percentage in the casting for good practice. You would have to add about 130 pounds. As the addition of large amounts of practically cold material has a decidedly chilling action, it would be better policy to use 50 per cent ferro-silicon. It is necessary to have approximately 0.30 per cent silicon in the casting to insure soundness. This will require about 30 pounds of 50 per cent ferro-silicon, taking oxidation into consideration. The amount of iron you add is very small and will not give 0.21 per cent carbon if your blowing method is correct. It is always advisable to blow flat, which will give you, before recarburizers are added, approximately 0.10 per cent carbon and 0.04 per cent manganese and silicon respectively. It is impossible to recommend the correct amounts of iron and alloys, as they are determined entirely by the method of blowing. If you cut the flame high as the amount of iron added seems to indicate, it is doubtful if you have sufficient silicon, manganese, aluminum or titanium to thoroughly deoxidize the bath and still leave the necessary amount of silicon and manganese in the metal.

## Strong Castings

*By W. J. Keep*

*Question:*—We have been asked to figure on cast iron work consisting of an approximately cylindrical piece about 3 inches long and 2 inches in diameter, on which considerable machining must be done, including the cutting of some fine threads. The metal must withstand a tensile test of 13 long tons, or 29,120 pounds, and a crushing test of 45 long tons, or 100,800 pounds. What will constitute the best mixture of iron to accomplish the desired result, bearing in mind that the metal not only must conform to the required tests, but must machine freely?

*Answer:*—This is a question of mixture, not methods. Such a metal should be made in an air furnace. If you wish to make it in a cupola, you must add steel until you get what you want. Use a mixture of your stock irons that has proved strong and charge with such a mixture from 10 to 20 per cent of steel scrap. Place a small piece of pure aluminum in the ladle to make the castings sound. If you do not wish to use steel, you can use close-grained, low-silicon irons, say No. 3 foundry, and then soften by placing in the ladle enough 50 per cent ferro-silicon to bring the silicon to about 2.00 or 2.5 per cent. The ferro-silicon is placed in the ladle and the iron poured onto it. This will make a close-grained, strong iron soft enough to machine well. It will be necessary for you to find by experiment which method will be most satisfactory.

The C. F. Sammond Co., Milwaukee, agent for the Hill & Griffith Co., Cincinnati, manufacturer of foundry supplies and equipment, has changed its name to the Foundrymen's Supply Co.

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## *A Call to Duty*

UNDER the auspices of the American Foundrymen's Association, the casting manufacturers of the United States will assemble again in annual convention in Boston during the week of Sept. 24. In view of the events that appear to be leading inevitably to war with Germany, it is appropriate that this year's meeting be held amid the historic environment of Bunker Hill. For in this modern war of science, machines and organization, the producers of castings are called upon to play no insignificant part. American foundrymen are, therefore, facing grave and momentous responsibilities.

Will they rise to the occasion?

We think they will, but not without great effort.

In the leading article in this issue, Mr. Custer clearly points out the difficulties encountered in producing shells, grenades and other castings for military purposes. You should read every line of this timely contribution, as well as the one following on the manufacture of French grenades. You will then understand why ordinary rough-and-ready shop practice will not do at all for war work, and you will appreciate that the success of American foundrymen in doing their bit for their country in this critical hour depends on the extent of their technical knowledge.

One of the great agencies for the dissemination of this technical information—that may prove vital in the days to come—is the American Foundrymen's Association. Hence, it is essential that the program this year contain a maximum amount of technical information, for the benefit of the many foundrymen who soon may be struggling with an extraordinary problem. The 1917 meeting should perform a distinct service to the country.

To accomplish this end, foundrymen everywhere must co-operate unsparingly and give unstintingly of their time and knowledge for the preparation of papers and for the execution of the work of the technical committees of their association. The call to duty has sounded.

## *Trade Outlook*

A STRONG demand for castings, maintained by domestic industrial activity and stimulated by the eleventh-hour preparedness movement keeps foundries operating at full capacity. Heavy purchases of foundry iron for prompt, second half and 1918 delivery at prices having an upward tendency are important factors of the present market situation. No. 2 foundry iron is quoted at $37 to $38, valley; $37, Chicago; $37 to $38, Cleveland; $39 to $40, Buffalo; $39 to $40, Philadelphia; and $30, Birmingham. Malleable is held at $37 to $38, valley; $37, Chicago; and $39 to $40, Buffalo. Low phosphorus sells at $60 to $61, Pittsburgh, and $65, Philadelphia. Prompt coke is quoted at $10, Connellsville.

# New Equipment for the Foundry and Pattern Shop

***Small Squeezer-Type Molding Machine of Simple Design—Split-Hand Motion Study Watch—New Safety Sand Blast Machine—Foundry Air Compressor***

THE demand for a small and simple molding machine has influenced many manufacturers of foundry equipment to develop various types of pneumatically operated machines. An air squeezer of extremely simple design has been developed by the Federal Malleable Co., West Allis, Wis. As shown in the accompanying illustrations, the working parts of the machine are mounted on a vertical standard railroad rail of heavy section. This material was selected after trials had been made with light I-beams and heavy pipe. It will be noticed from Fig. 2 that the upper head is pivoted to a bracket bolted to the rail. This head swings on a tapered bolt and is so balanced that but little effort is required to swing it. The lower table and cylinder rests on a heavy casting securely bolted to the rail. The bench plate is 21 inches long and 14 inches wide, while the squeezer head is 14 inches long by 8 inches wide. This provides for a wide range in the size of flasks accommodated. The cylinder and piston are said to be constructed in such a manner that it is practically impossible for sand to interfere with the movement of the piston. The action of the piston is controlled by a separate valve made of gray iron and designed for unusually sensitive regulation. A set screw in the valve provides a means of introducing oil for lubrication and a spring holds the seat of the valve in place rendering it air tight. The construction of this valve is said to prevent the possibility of sand entering the working parts.

The machine can be operated at from 60 to 80 pounds air pressure and exerts a squeezing pressure of approximately 4,000 pounds.

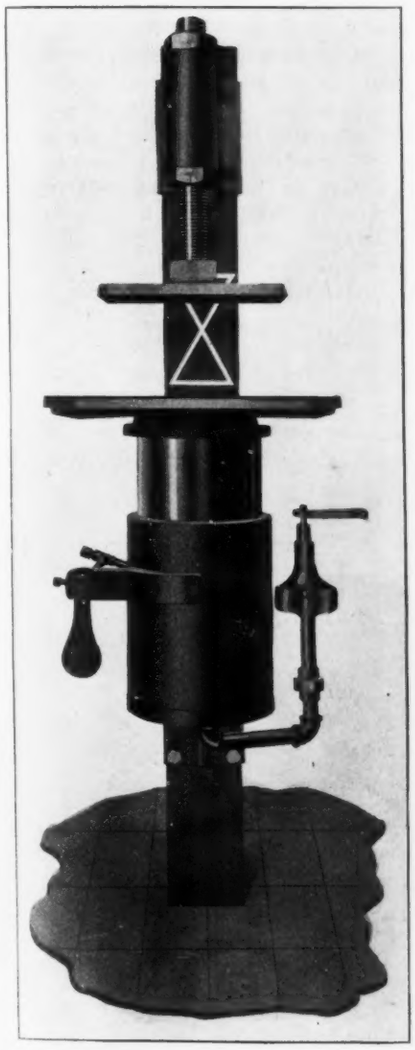

FIG. 1 — FRONT VIEW OF MOLDING MACHINE MADE BY FEDERAL MALLEABLE CO.

MOTION STUDY WATCH

## Motion Study Watch

A decimal computed dial is a feature of the new motion study watch shown in the accompanying illustration. The dial of this split-hand watch is divided into tenths and hundredths of a minute and has legible figures spaced at intervals representing two-hundredths of a minute. A glance at the dial immediately indicates the hourly production or quantity. The combination of this dial with a split-hand watch makes it possible in one observation to obtain both the productive and non-productive time of an operation. The two hands may both be controlled from the crown, or if they are to be used separately, one may be controlled from a side plug. For instance, the crown-controlled hand may be used to determine the gross time and the side-controlled hand may be used to take out the non-productive time or the delays. With one reading, therefore, both the net and the gross time is obtained. This instrument has been developed by Mortimer J. Silberberg, 122 South Michigan av-

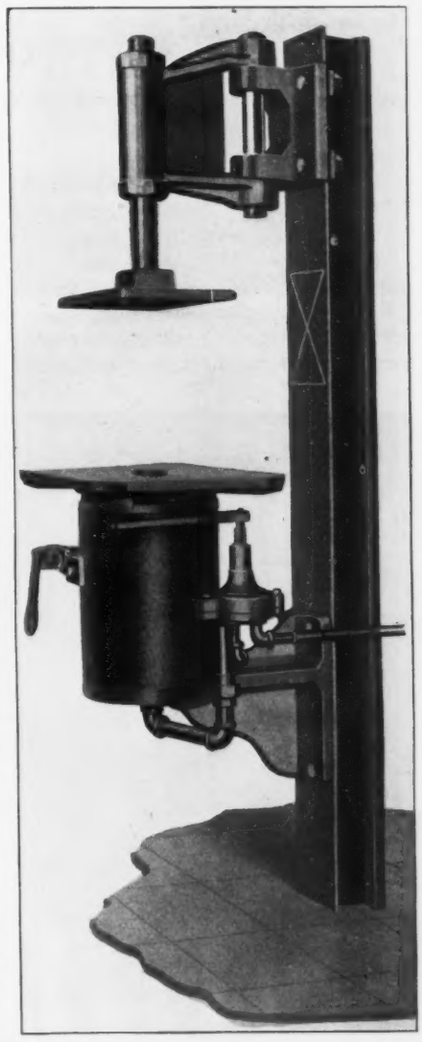

FIG. 2 — SIDE VIEW OF MOLDING MACHINE SHOWING SWINGING HEAD

enue, Chicago. The motion study watch embodying the decimal computed dial is a development of the time study instrument which was described in the April, 1916, issue of *The Foundry*.

## A New Departure in the Design of Sand Blast Apparatus

The American Foundry Equipment Co., New York, has recently developed a new type of sand-blast room in which the sand-blast nozzle is operated by a workman stationed outside the room and protected from the blast and dust by a fine-mesh screen. This new machine, which is shown in the accompanying illustrations, is a development of a machine brought out by the company some years ago. The original rotary-table apparatus required the presence of the operator within the room to direct the blast. The new type consists of the standard 5, 6 and 7-foot tables in which the regular room is replaced by a semicircular casing with the top slanted off and covered with fine-mesh screen through which the operator sees his work. An opening for the blast is provided by a horizontal slit in a soft-rubber curtain about 3 feet from the floor. The room is illuminated by two special sand-blast lamps. No bucket elevators or air elevating devices are employed.

The original rotary-table room required the presence of a man on the inside to direct the blast and to turn over the work and, where only one room was operated, it was not profitable to have a man on the outside to turn the work and to load unless there was other work for him to do while the blast was in operation. The new type is said to be suitable for any number of installations since the operator may, at any time, shut off the control valve, turn the table and load or unload. If the work is complicated he may turn it as many times as is necessary. Such operation is practical because the operator is entirely removed from the sand-blast area and does not have to wear helmet, coat or respirator, and therefore is not encumbered any more by special clothing than he would be if he were loading castings.

This type of room is designed particularly for use where the castings are not intricately cored and do not require more than one or two turnings to expose all sides to the blast. When cleaning castings which have a deeply recessed core, the operator is afforded protection from the black dust of the cores which would tend to blow directly into his face were he not protected from the blast.

---

McLain's System, Milwaukee, announces that it has sold a three-ton open hearth steel furnace to the George H. Smith Steel Casting Co., Milwaukee. The work of constructing the furnace has already commenced and it is expected it will be in shape to melt steel April 15.

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"The Crucible Problem Solved" is the title of the 12-page folder issued by the Monarch Engineering & Mfg. Co., Baltimore. It illustrates and describes an extensive line of furnaces for melting brass, copper, bronze, aluminum, nickel, ferro-alloys, iron, semi-steel, etc., without the use of crucibles. These furnaces are what are known as the open-flame type and in addition reverberatory scrap melting furnaces, tilting furnaces, ladle heaters and core ovens are shown.

## Air Compressor for Foundry Use

The accompanying illustration shows an air compressor built by the Sullivan Machinery Co., Chicago, and recently installed by the American Bronze Co. in its plant at Berwyn, Pa. This compressor is a tandem, two-stage, belt-driven machine, with air cylinders 12 and 7.5 inches in diameter, with 10-inch stroke. The machine is operated by a 50-horsepower alternating-current two-phase motor, supplied by Fairbanks, Morse & Co. The compressor furnishes compressed air at 90 pounds pressure and, at its rated speed of 235 revolutions per minute, has a displacement of 306 cubic feet of free air per minute.

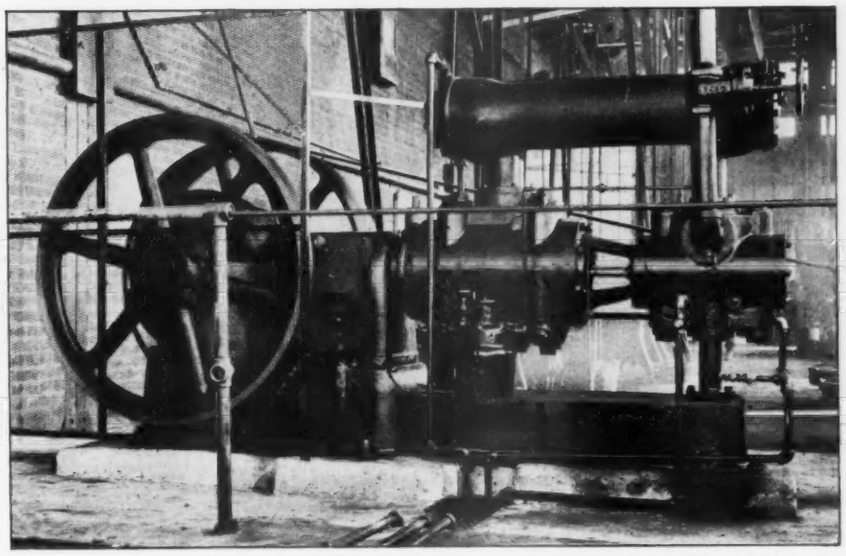
The compressor operates at constant speed, and, although the load varies widely, it is stated that the air pressure is maintained constant at 90 pounds per square inch by means of an improved unloader. An interesting feature of this unloader is an arrangement for catching any oil or foreign matter in the air line which would otherwise clog the pilot valve.

As shown by the illustration, the machine is of the enclosed frame

FIG. 1—THE OPERATOR GUIDES THE NOZZLE FROM THE OUTSIDE AND WATCHES THE WORK THROUGH THE SCREEN

FIG. 2—THE HOSE OPENINGS ARE APPROXIMATELY THREE FEET FROM THE FLOOR OF THE REVOLVING TABLE

type, with dust-tight removable covers over the main bearings and at each side of the cross-head guides. The main working parts of the machine are oiled by a splash system while the air cylinders are equipped with sight feed lubricators. An intercooler of an aluminum tube pattern is employed, the air being forced across the cooling tubes three times by means of baffle plates in its passage from the low pressure to the discharge cylinder. Both cylinders are equipped with inlet and discharge valves of the automatic poppet pattern, fitted with special double-cushioned springs which are quiet in operation.



AN AIR COMPRESSOR DESIGNED FOR FOUNDRY USE

## Novo Engine Co. Shares Profits

The Novo Engine Co., Lansing, Mich., has declared its second annual wage dividend. All employes who have been continuously in the service of this company for a period of 12 months prior to Dec. 1, 1916 will receive an amount equal to 5 per cent of their total wages earned during the year and to those who have been in the employ of the company continuously for a period of six months, but less than 12 months, an amount equal to 2½ per cent of their wages will be paid.

The Chicago Foundrymen's Club has issued a calendar of the year 1917 in which the dates of the regular monthly meetings throughout the year are cleverly indicated. The calendar also is arranged so that it is possible to find the day of the week on which any date falls. The calendar is printed in two colors on heavy board and is provided with a ferrule so that it may easily be hung on the foundry wall.

Simon D. Lauffer, 83 years old, died at his home near Irwin, Pa., recently. At one time he was interested in the foundry owned by Lauffer, Hurst & Co., and later he was connected with the Hockensmith Wheel & Mine Car Co. At the time of his death, he was vice president of the Greensburg Foundry & Machine Co.

According to figures compiled by the American Iron and Steel Institute, the pig iron production in the United States in 1916 totaled 39,434,797 tons, as compared with 29,916,213 tons the previous year and 23,332,244 tons in 1914. This production sets a new high mark. Pennsylvania, of course, leads with an output of 16,506,284 tons, which is 41.86 per cent of the total produced, and Ohio ranks second with 8,602,895 tons, which is 21.81 per ment of the total. The production of charcoal iron likewise showed a big increase over 1915 with an output of 372,411 tons, against 2,96,152 tons the previous year. Cold blast charcoal iron, however, showed only a slight increase over the previous year and a tremendous falling off over 1914. Last year the total produced by this process was 5,323 tons, as compared with 5,302 tons the previous year and 9,294 tons in 1914.

## Philadelphia Foundrymen Meet

A meeting of the Philadelphia Foundrymen's Association was held Wednesday evening, March 7, at the Manufacturers' Club. The officers of the engineering and construction and repair departments of the United States navy were guests at the meeting. The papers presented discussed navy yard subjects and are as follows: "The Buildings, Lighting and Ventilating", by Mr. Buckwalter; "Cranes in the Navy", by Mr. Austin, and "Foundry Equipment", by Mr. Kremer.

Edward Salts, formerly with the foundry of the Jeffrey Mfg. Co., now is plant superintendent of the Lewis Foundry & Machine Co., Groveton, Pa.

# WHAT THE FOUNDRIES ARE DOING

*Activities of the Iron, Steel and Brass Shops*

S. E. Parker, 1800 North Francisco avenue, Chicago, will build a foundry.

The R. E. Parsons Foundry Co., Bridgeport, Conn., will erect an addition to its plant.

The Pennybacker Co., Emaus, Pa., will erect a one-story, 94 x 551-foot addition to its foundry.

The Plymouth Foundry & Machine Co., Plymouth, Wis., will erect a foundry at a cost of $25,000.

The Rath Metal Products Co., 1335 Liberty avenue, Pittsburgh, has changed its name to the Gloekler Foundry Co.

The Jacob & Kugler Foundry Co., Easthampton, Mass., will build a brick, 60 x 60-foot foundry on East street.

The A. & M. Casting Co., 10611 Quincy avenue, Cleveland, will build a steel and brick foundry, 62 x 202 feet.

Two additions, which will cost approximately $18,000, will be made to the plant of the Akron Foundry Co., Akron, O. This company makes gray iron castings.

Plans have been completed by the Saginaw Malleable Iron Co., Saginaw, Mich., for a plant, 136 x 400 feet, to cost $200,000.

La Fonderie d'Acier des Trois Rivieres, Trois Rivieres, Que., Can., will build an addition to its foundry at a cost of $100,000.

The Pier Machine Works, New York City, has been incorporated to engage in the manufacture of metallic castings, pumps and

winches, with a capital stock of $50,000. The incorporators are E. Praxmarer, A. Foshay, A. G. Thaanum, 92 Haven avenue.

Davidson & Weiss, architects, 53 West Jackson boulevard, Chicago, will receive bids until May 10 on a foundry to cost $50,000.

The Pressed Steel Automobile Lug Co., Crookston, Minn., contemplates the erection of a new plant, which will include a foundry.

The Ross-Meehan Foundry Co., Chattanooga, Tenn., will erect an annealing shop, 140 x 200 feet, of steel and brick construction.

Contract has been awarded by the Essex Smelting & Refining Works, Irvington, N. J., for the erection of a brass foundry, 22 x 152 feet.

The J. W. Sanders Foundry & Machine Co. will build a $25,000 foundry at DeRidder, La. J. W. Sanders, Shreveport, La., is president.

The Osborne Casting Co., Racine, Wis., has been incorporated with a capital stock of $10,000 by John H. Osborne and Charles Holmes.

The Maytag Co., Newton, Ia., manufacturer of agricultural implements, will build a 1-story, 90 x 100-foot foundry at a cost of $25,000.

A foundry and machine shop will be added to the Litchfield, Ill., plant of the American Radiator Co., 816 South Michigan avenue, Chicago.

The Bay View Foundry Co., Sandusky, O., which has tripled its capacity during the past 18 months, contemplates doubling its present capacity.

The Marshall Foundry Co., Pittsburgh, contemplates erecting an addition to its plant at Black Lick, Pa. The estimated cost is $100,000.

Plans have been prepared for a 125 x 700-foot structural-steel foundry building to be erected by the Ohio Steel Foundry Co., Lima, O.

Contract has been let for the erection of a one-story, 27 x 102-foot foundry for the Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

The Atlas Foundry & Machinery Co., Tacoma, Wash., contemplates the erection of a foundry and pattern shop, 44 x 225 feet, at a cost of $50,000.

The Ireland & Mathews Mfg. Co., Detroit, will build a plant which, with the equipment, will cost approximately $500,000. A large brass foundry is included.

The Garrett Foundry Co., Brooklyn, N. Y., has been incorporated with $50,000 capital stock by C. H. Fowler, A. W. Trotter and J. C. Garrett, 43 McDonough street.

The Clarksville Foundry & Machine Co., Clarksville, Tenn., has been incorporated with a capital stock of $10,000 by T. B. Foust, S. J. Lowe, H. N. Leach and others.

M. L. Oberderfer, 804 East Water street, Syracuse, N. Y., has awarded the contract for a one-story and basement, 50 x 101-foot core shop addition to his brass foundry.

The Swandler Brass Mfg. Co., Cleveland, has been incorporated with a capital stock of $40,000 and contemplates erecting a plant for the manufacture of plumbers' brass goods.

The Victor E. Knecht Foundry Co., Harrison, O., has been incorporated with a capital stock of $6,000. The foundry of the Campbell Bros. Mfg. Co. has been acquired.

The Superior Steel Casting Co., Benton Harbor, Mich., will erect an addition to its foundry, 140 x 142 feet, which will be equipped with a 10-ton crane and an electric furnace.

Plans have been completed by the American Brass Co. for a 98 x 320-foot foundry of brick and steel construction to be erected at Ansonia, Conn. The estimated cost is $150,000.

The National Malleable Castings Co., Cleveland, is building a foundry at Woodhill road and Woodland and Quincy avenues, which will be 625 x 725 feet. The estimated cost is $500,000.

The Link Belt Co., Indianapolis, Ind., will build an addition to its foundry at a cost of $30,000. The building will be T-shaped, the smaller portion 106 x 140 feet and the larger 106 x 250 feet.

The Kawalle Bros. Co., Manitowoc, Wis., has been reorganized with $20,000 capital and will now be known as the Manumotors Co. The erection of a foundry and machine shop is contemplated.

The stove foundry of the old Smith & Anthony Co. at Wakefield, Mass., was purchased by the Gibby Foundry Co., East Boston, and will be reopened for the manufacture of light machine castings.

The Wadsworth Foundry Co., Wadsworth, O., has been incorporated with a capital stock of $15,000 by William F. Ries, William A. Helmick, C. C. Patterson, Thomas J. O'Brien and Joseph Burgess.

The Harris-Hanson Foundry Co., Stamford, Conn., which has been in business in that city for about a year, has just been incorporated with $25,000 capital stock. Benjamin Harris is president of the company.

The Regent Brass Foundry Co., Marysville, O., has been incorporated with a capital stock of $30,000. The incorporators are Joseph J. Klein, Alfred V. Birnbaum, A. J. Hale, S. M. Davis and E. Weinberger.

The McWane-Tennessee Cast Iron Pipe Co., Rockwood, Tenn., has been incorporated with $100,000 capital stock by F. W. Climer, of Rockwood; J. M. Baker, of Harriman, Tenn., and John R. McWane, Birmingham, Ala.

The Walker Foundry & Machine Co., Pittsburgh, has been incorporated with a capital stock of $100,000 to engage in the manufacture of machinery. The incorporators are W. J. Walker, A. P. Manning and A. F. Hickey.

The Ramey Mfg. Co., Columbus, O., has been incorporated to conduct a foundry business with a capital stock of $50,000. E. J. Ramey, L. S. McKnight, McGee Sweptson, J. A. Sibley and R. E. Pfeffer are the incorporators.

The Warren Electric Steel Co., Warren, Pa., has been organized to engage in the manufacture of electric steel castings. R. T. Harris, general manager, now is receiving bids for the erection of the plant and the necessary equipment.

The De Witt Mfg. Co., Russellville, Ark., has been incorporated to engage in the manufacture of carburetors, with $25,000 capital stock, by D. M. DeWitt, J. F. Hogins and W. F. Bonds. A foundry and machine shop will be operated.

The Irondale Foundry & Machine Co., Birmingham, Ala., has been incorporated with a capital stock of $10,000. A plant will be built for the manufacture of sash weights. J. P. Beggs is president and George W. Dyer secretary and treasurer.

The plant of the Whiteley Malleable Casting Co., Muncie, Ind., burned last November, will be replaced by a new plant which will increase the capacity by one-third. The buildings will be of brick, steel and concrete construction and will cost approximately $300,000.

The Bronzo Alumina Corporation, Tonawanda, N. Y., has been incorporated with $16,000 capital stock to engage in the manufactory of aluminum, silicon, bronze and iron castings. The incorporators are F. A. Redner, J. E. Kaufmann and J. A. Willing, 141 Masten street, Buffalo.

Samuel Harris, Galt, Ont., and Max Goldman, Chicago, have completed negotiations with the Windsor, Can., board of trade for the purchase of 1½ acres on which will be built a $10,000 brass foundry. The firm contemplates occupying the old Coldwell Ideal Co. plant for the present.

The Standard Steel Co., recently incorporated with $50,000 capital stock to engage in the manufacture of farm and stable equipment, has taken over the business of the Abbottsford Mfg. Co., Abbottsford, Wis. The new company contemplates the erection of a two-story building, 60 x 20 feet and a foundry, 60 x 60 feet.

The buildings which will be erected by the Axelson Machine Co., Los Angeles, Cal., are of the following size: Foundry, 100 x 155 feet; machine shop, 130 x 375 feet; pattern shop, 25 x 80 feet; pattern storage, 25 x 80 feet; forge shop, 25 x 75 feet; office, 25 x 100 feet and garage, 25 x 100 feet. These dimensions were incorrectly given in the March issue.

Frank E. McIntyre, now general superintendent of the National Steel Foundries, Milwaukee, a part of the National Brake & Electric Co., has organized the Hercules Casting Co. with a capital stock of $400,000. The new company will establish an open-hearth steel foundry with a capacity of 1,200 tons per month in Milwaukee. The main foundry will be 70 x 500 feet, with a 60-foot bay, and the equipment will consist of two open-hearth furnaces of 20 to 25 tons capacity, to be served by electric traveling cranes. The officers of the company follows: F. E. McIntyre, president and general manager; J. J. McGovern, vice president; E. B. Gennrich, secretary and Francis E. McGovern, general counsel.

## New Trade Publications

FIRE ALARM AND DETECTOR.—Illustrations and a description of an automatic fire alarm and detector recently put on the market are contained in a circular issued by the New York Brass Foundry Co., 102 Centre street, New York. This apparatus consists of an electric bell in conjunction with an instrument designed on the principle of a thermometer. It may be used in all kinds of buildings, in the holds of vessels and wherever there is risk of fire.

MELTING AND REFINING FURNACES.—The Monarch Engineering & Mfg. Co., Baltimore, has issued a 12-page booklet descriptive of its line of furnaces for melting and refining brass, copper, bronze, aluminum, nickel, ferro-alloys, iron, semi-steel, gold, silver, cyanides, ores, etc. These furnaces are designed to operate with oil or gas as a fuel. The booklet contains numerous illustrations and a complete list of dimensions for each size of furnace. The booklet also contains a description of the tilting reverbatory type of furnace manufactured by this company.

VACUUM PUMPS. — The Ingersoll-Rand Co., New York City, recently issued two catalogs devoted to dry vacuum pumps, covering straight line and duplex types. Both machines which are equipped with Ingersoll-Rogler valves, are capable of maintaining a high vacuum and will handle discharge pressures of several pounds. The maximum degree of vacuum possible varies between the different machines to within 0.6 inches of the barometer. The pumps are offered in steam and power-driven types in a large range of sizes and capacities. Both catalogs are well illustrated in colors and show the machines in whole and in section.